Alberta

MUNICIPAL AFFAIRS

Innovative Housing Grants Program

STRUCTURAL TESTING
OF THE
NASCOR II R20 WALL SYSTEM
FOR
UNITED STATES PRODUCT ACCEPTANCE

MAY 1988

Prepared by:

CANO STRUCTURES INC.

The views and conclusions and the recommendations made in this report are entirely those of the authors and should not be construed as expressing the opinions of the Alberta Municipal Affairs.

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FOREWORD

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EXECUTIVE SUMMARY

Introduction

Cano Structures Inc. has been successfully producing the NASCOR II R20 wall system in Canada for four years and, to date, about 6000 units have been constructed. Over the past two years Cano Structures Inc. has received numerous invitations to quote on projects in the U.S.A. as well as many opportunities to sell manufacturing licenses to American - based operations.

In order to enter the U.S.A. market, however, the NASCOR II R20 wall system had to be evaluated by U.S. building code authorities to determine its compliance with their building code. The International Conference of Building Officials (ICBO) was the authority chosen to conduct the evaluation. A major requirement of their evaluation process was to have the wall system structurally tested by a testing agency recognized by the ICBO. Cano Structures Inc. therefore sought assistance under the Innovative Housing Grants Program to conduct structural testing in accordance with ICBO criteria and to have ICBO perform an evaluation which results in a formal acceptance of the wall system.

Testing Program

Warnock Hersey Professional Services Ltd. were engaged to conduct the structural testing and to aid in the application/evaluation process by ICBO. The testing program consisted of subjecting wall panels to the following:

(i) Axial load test - three wall panels measuring 1220 mm x 2440 mm (4'x8') by 140 mm (5 1/2") thick and four wall panels measuring 1220 mm x 3048 mm (4'x10') were tested. NASCOR II R20 columns were spaced at 610 mm (24") on center.

(ii) Tranverse load test - three wall panels measuring 1220 mm x 2440 mm (4'x8') by 140 mm (5 1/2") thick and two wall panels measuring 1220 mm x 3658 mm (4'x12') by 140 (5 1/2") thick were tested. NASCOR II R20 columns were spaced at 610 mm (24") on center.

(iii) Racking load test - three wall panels measuring 2440 mm x 2440 mm (8'x8') were tested with NASCOR II R20 columns spaced at 600 mm (24") on center.

(iv) Fastener test - the 76 mm (3") wood screws used in the NASCOR wall system were tested for shear and pull-out values.

(v) Adhesive test - the PVA adhesive used by Cano Structures Inc. in Canada was compared in shear tests to the urethane adhesive proposed for use in the U.S.A.

Test Results

Test results were used to develop empirical formulae and allowable load tables (axial and transverse). The test results also allowed ICBO a basis of comparison to determine whether the NASCOR II R20 wall system conformed to the ICBO's Uniform Building Code.

Test results and ICBO evaluation showed that the NASCOR II R20 wall system complies with the Uniform Building Code. ICBO therefore formally accepted the wall system by issuing ICBO Evaluation Service Inc., Evaluation Report 4491.

1.0 INTRODUCTION

The NASCOR II R20 system, manufactured by Cano Structures Inc., has met with enthusiastic market response in Canada as a highly energy efficient wall system for residential housing, including low-rise multi-family housing. During the last two years many opportunities have arisen for Cano Structures Inc. to pursue international markets. Having received numerous invitations to quote on projects in Hawaii, California, and Arizona as well as Grenada and St. Lucia, Cano Structures Inc. resolved to actively seek entry to the large U.S. and U.S. controlled market.

In order to sell within the American market, it is necessary to secure product acceptance from one of the three national building code regulatory agencies. Of these, the International Conference of Building Officials (ICBO) is the most widely recognized and is the publisher of the Uniform Building Code. Consequently, it was decided to pursue ICBO product evaluation and acceptance for the NASCOR II R20 system.

In addition to its structural certification, Cano sought to secure a one-hour fire resistance rating for its system. This rating would enable the use of the NASCOR II R20 system in some multi-family construction. The system currently holds a recognized one-hour fire rating; however, the necessary construction details were considered to be too expensive and limited the product's competitiveness. Consequently, Cano Structures developed more cost effective details and subjected the revised system to certification testing. The NASCOR II R20 system was tested according to

ASTM standard E72-80, "Standard Methods of Conducting Strength Tests of Panels for Building Construction" and CAN 4-5101 "Standard for Fire Endurance Testing of Building Components". This latter test is essentially identical to its American counterpart, ASTM E119-83, and is acceptable to ICBO.

Cano Structures engaged the services of Warnock Hersey Professional Services Ltd. of Coquitlam, B.C.. Warnock Hersey is a testing and evaluation service which is recognized by U.S. authorities. They determined which building code authority to apply to, and what testing requirements needed to be met to acquire product acceptance of the NASCOR II R20 system.

This report describes the results of the work and provides related background information. The material has been organized as follows: Section 2 describes the components of the NASCOR II R20 system; Section 3 identifies building code requirements and test objectives; Section 4 outlines test procedures; Sections 5 and 6 discuss test results and product acceptance.

2.0 NASCOR II R20 WALL SYSTEM DESCRIPTION

2.1 General Description

The NASCOR II R20 wall system is designed to be used as an exterior loadbearing wall where its quality of manufacture and its energy efficiency provide the most benefit for residential and light commercial applications. The wall system is composed of thermally efficient NASCOR II R20 columns (columns are composed of a polystyrene core sandwiched between two wood members) interlocked with NASCOR Type 1 expanded polystyrene insulation panels, polystyrene splines, a 38 x 140 (2x6) bottom plate, and a 38 x 140 (2x6) top plate. Where required, rough openings are framed in by NASCOR II R20 end posts, 38 x 140 (2x6) cripple studs, NASCOR lintels, and a 38 x 140 (2x6) window sill plate.

The NASCOR II R20 wall system is a factory-fabricated wall system. Basically, the NASCOR II R20 columns, insulation panels, splines, top and bottom plates, etc. are combined in the factory to form wall panels of lengths (which are based on a customers blueprints) that can be easily handled by two men.

The wall panels are then trucked to the jobsite where the conventional framers tilt them up into place in sequential order and join them by a cap plate. See Figure 2.1 for a typical corner detail where two wall panels join.

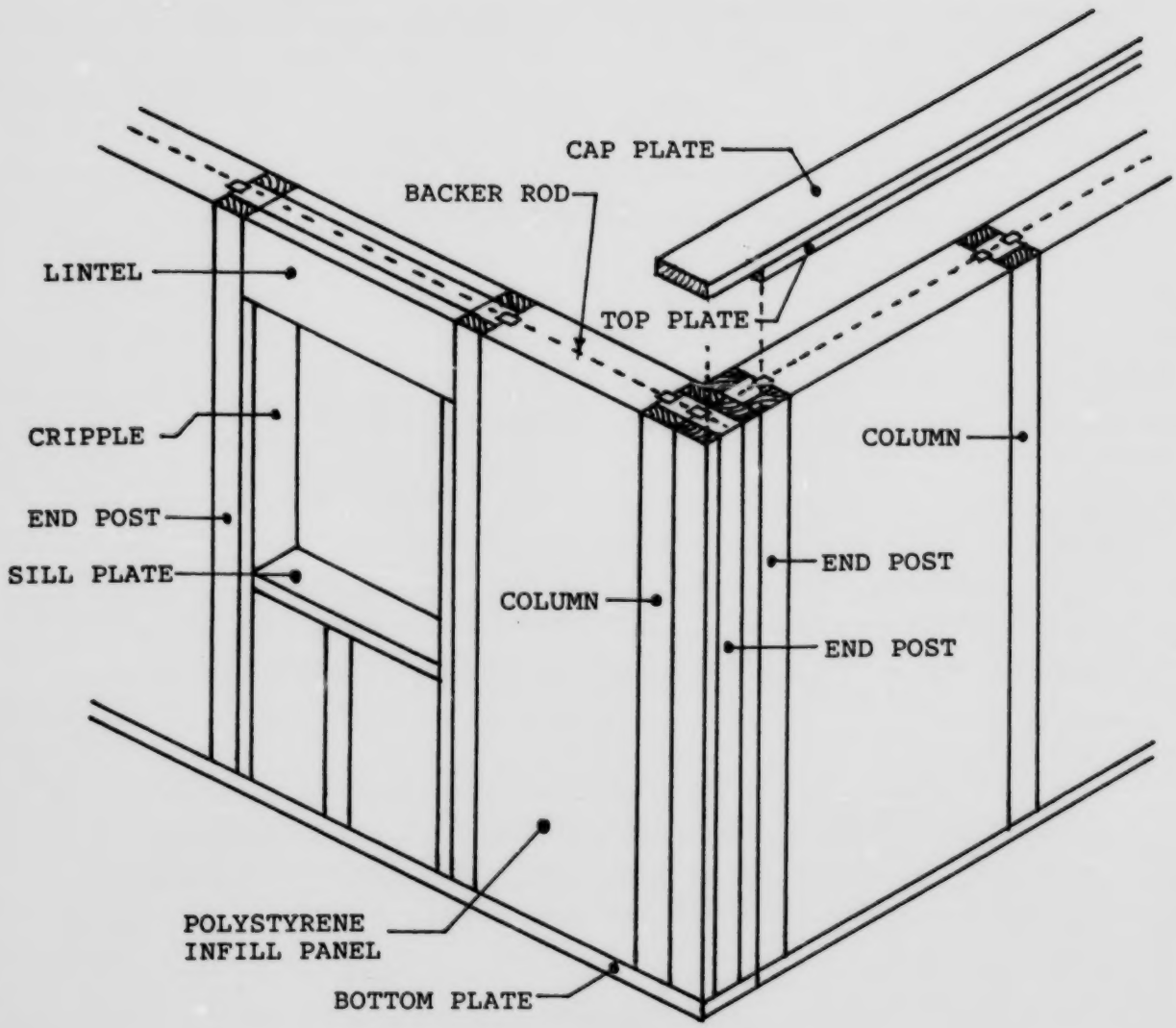
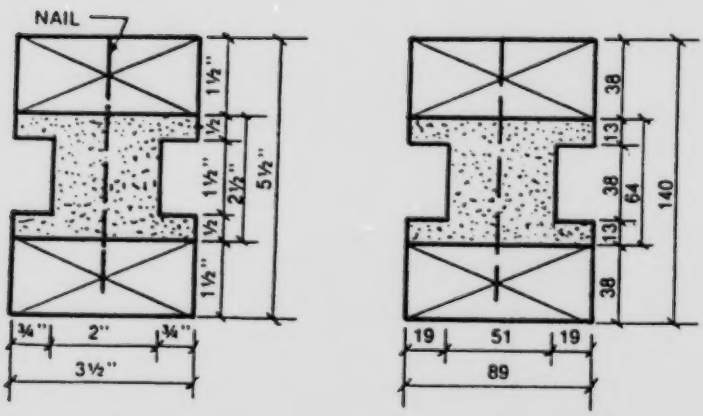


FIGURE 2.1 - ISOMETRIC OF TYPICAL NASCOR WALL PANELS

2.2 NASCOR II R20 Standard Column

The NASCOR II R20 column consists of a polystyrene core sandwiched between two 38x89mm (2x4) wood studs (Figure 2.2). The polystyrene core is attached to both studs with an adhesive and the section is nailed together 450 (18") on center with 127mm (5") resin-coated nails. The columns can be up to 3048mm (10 feet) in height. The polystyrene core is profiled on both sides to facilitate air-tight connections of columns and polystyrene infill panels by use of splines. Depending on load conditions and wall height, the columns are spaced at 300, 400 or 600mm (12", 16" or 24") o/c. The most common spacing is 600mm (24") o/c.



Imperial Dimensions

Metric Dimensions

FIGURE 2.2 - NASCOR II R20 COLUMN

2.3 NASCOR II R20 End Post

The NASCOR II R20 end post is essentially the same as a column cripple, except the notch is not removed during assembly. The polystyrene core of an end post is profiled on one side only. End posts are used at all corners and rough openings. The flat face is placed to the exterior of the corner or opening so that a smooth surface is created and the greatest thickness of insulation is achieved. Placement of the end posts, as shown in Figure 2.3, also permits a nailing point for exterior and interior cladding.

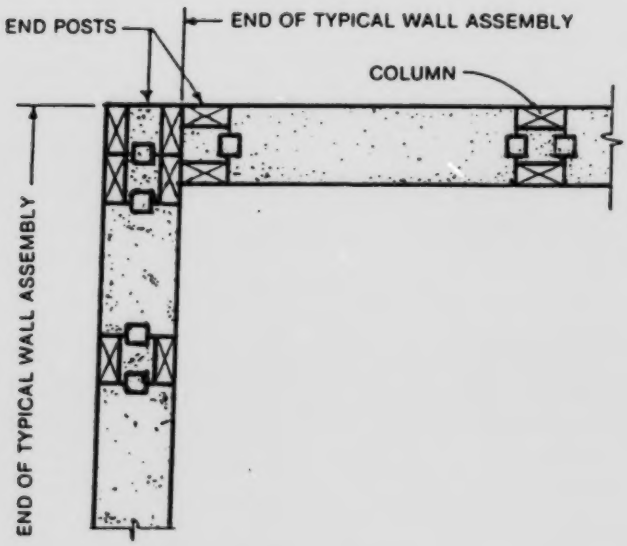
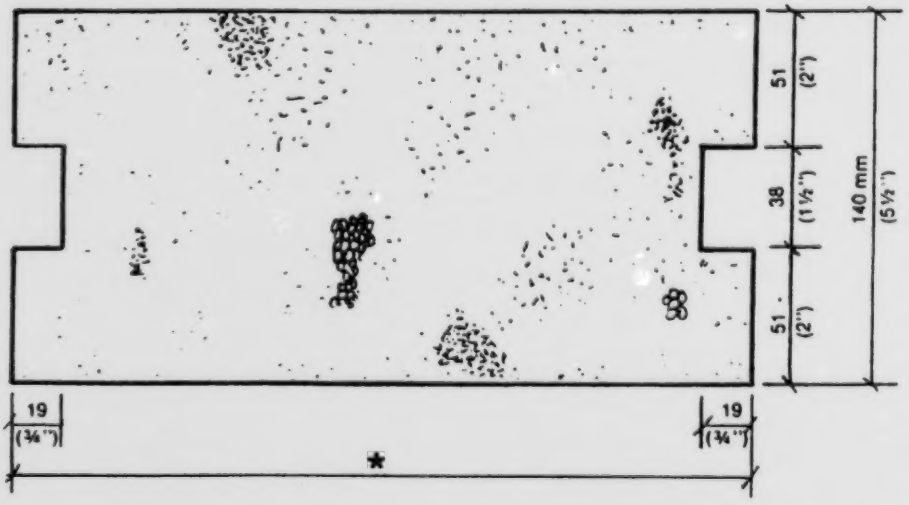


FIGURE 2.3 - NACSOR II R20 END POST

2.4 NASCOR II R20 Infill Panel

The NASCOR II R20 infill panel is a 140mm (5 1/2") thick panel of NASCOR Type I, expanded polystyrene insulation with each end of the panel having a 38mm (1 1/2") wide by 19mm (3/4") deep keyway cut out. The keyways of the infill panels are intended to interlock with the keyways of columns, end posts, or cripples by use of splines (see Section 2.7 for spline description). Figure 2.4 below shows a plan view of a typical infill panel.



* Width of panels vary with stud spacing:
Studs at 305 (12") o/c: panel width is 216 (8 1/2")
Studs at 406 (16") o/c: panel width is 317 (12 1/2")
Studs at 610 (24") o/c: panel width is 521 (20 1/2")

The above widths are standard manufactured widths. To accommodate narrower infill panels, the appropriate standard panel is simply cut to the required width and the keyway recut.

FIGURE 2.4 - NASCOR II R20 INFILL PANEL

2.5 Lintel

The standard NASCOR II R20 lintel consists of a 64mm (2 1/2") polystyrene spacer section sandwiched between two rows of 38 (1 1/2") thick wood members. The depth of the wood members is dependant on load conditions and may be obtained from tables in the appropriate building code. The polystyrene is adhered to both wood members and the entire section is nailed together with two rows of 125 (5") ardox spiral nails, spaced at 406 (16") o/c. The length of the lintel is, of course, dependent upon the width of the opening. The lintel is attached to the end post at each end with four 125 (5") screws (Figure 2.5). An ethafoam backer rod is installed at the connection of the lintel and column cripples to ensure a good air seal.

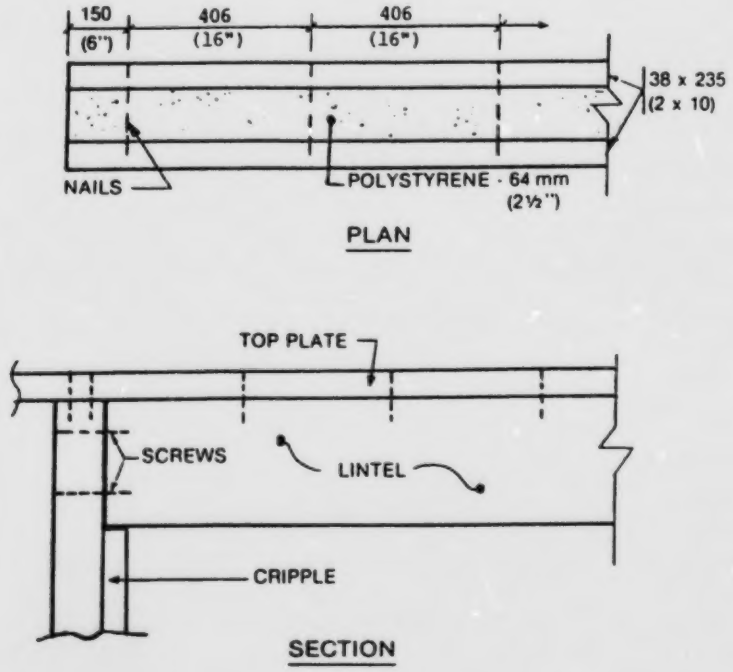


FIGURE 2.5 LINTEL DETAILS

2.6 Spline

The spline is a solid section of expanded polystyrene insulation measuring 38 x 38 (1 1/2" x 1 1/2") whose purpose is to act as an airlock and connecting mechanism between the various components of the NASCOR II R20 wall. It is a friction-fit installation which interlocks the keyways of the infill panels to the keyway of the columns, and end posts (See figure 2.1).

2.7 Top and Bottom Wall Plates

Each factory-assembled wall panel is joined together by the top and bottom plates. The plates consist of 38 x 140mm (2x6) wood members and are mechanically fastened to each column and post which form the wall panel with four 76mm (3") wood screws per column. To ensure a good air lock, a continuous ethafoam backer rod is placed under the plates before they are attached to the wall components. When the wall panels are erected at the building site, a cap plate is installed over the top plate. The cap plate (usually supplied by the builder) ties the wall panels together.

3.0 BUILDING CODE REQUIREMENTS AND TESTING OBJECTIVES

In order to sell the NASCOR II R20 wall system within the American market or an American-controlled market, it is necessary to secure product acceptance from one of the three national building code regulatory agencies. Of these, the International Conference of Building Officials (ICBO) is the most widely recognized in the U.S. and is the publisher of the Uniform Building Code. Consequently, it was decided to pursue ICBO product evaluation and formal acceptance of the NASCOR II R20 wall system in conformance with the Uniform Building Code.

3.1 Uniform Building Code Requirements

The following items are an outline of the critical portions of the Uniform Building Code with which the NASCOR II R20 wall system must comply in order to obtain an ICBO Evaluation Report:

(i) Chapter 12 - Requirements for Group R Occupancies
This chapter outlines where fire-resistive construction is necessary.

(ii) Chapter 17 - Requirements Based on Types of Construction
Section 1712 requires specific flame spread rating of not more than 75 and smoke-developed rating of not more than 450 for foam plastic insulation. This applies to the NASCOR polystyrene insulation. This section also requires the interior face of the foam plastic to be covered by a thermal barrier (such as gypsum board).

(iii) Chapter 22 - Type V Buildings
The NASCOR II R20 wall system will fall under the classification of Type V buildings.

(iv) Chapter 23 - General Design Requirements

The NASCOR II R20 wall system must be structurally analyzed and designed for the specific loads and load combinations described in this chapter.

(v) Chapter 25 - Wood

This chapter outlines allowable stresses for lumber and relates them to allowable design loads on building components. Specific building construction methods are also described for conventional construction including requirements for exterior wall construction. For example, listed below are some of the applicable code requirements for conventional construction practices:

(a) Loadbearing walls shall not support more than two floors and a roof

(b) Exterior walls shall be constructed with the size of fasteners and spacings in section 2516(j)

(c) Framing around rough openings shall be constructed in accordance with section 2517(g)4

(d) According to section 2517(g)3, 12.9mm (1/2") gypsum board on the interior face of an exterior wall provides suitable bracing for wind forces.

(e) Table 25-A-1 provides allowable stresses for various species of lumber

(f) All fastening for exterior walls must be done in accordance with Table 25-Q

(g) The allowable size, height, and spacing of wood studs for various load conditions in conventional construction are provided in Table 25-R-3

3.2 ICBO Evaluation Service Inc. Requirements

In order to receive an Evaluation Report for the NASCOR II R20 wall system, the ICBO Evaluation Service Inc. required that Cano Structures Inc. prove that the wall system complies with all applicable portions of the Uniform Building Code. More specifically, the ICBO Evaluation Service Inc. stipulated that the NASCOR II R20 wall system be evaluated in accordance with the "ICBO Acceptance Criteria for Sandwich Panels" (see Appendix A). This criteria outlines the test methods to be used, some structural design limits (such as safety factor of 3 and deflection limit of L/180), requirements for providing fastener details and/or tests, requirements for details and/or tests on the design of framing around rough openings, and requirements for adhesive (in this case the adhesive was to conform to "ICBO Acceptance Criteria for Sandwich Panel Adhesives" - see Appendix B).

3.3 Applicability of the NASCOR II R20 Wall System to Conventional Construction

Once evaluated and accepted as an alternative exterior wall construction by ICBO, the NASCOR II R20 wall system could be used and limited as follows:

(i) in Type V - N buildings (buildings allowed to be of combustible construction and requiring no fire resistance ratings)
(ii) for exterior wall heights up to 3048mm (10ft)
(iii) with column spacing up to 610mm (24") o/c
(iv) for axial and transverse loads as determined by structural testing and analysis of results
(v) with an approved thermal barrier on the interior face such as 12.9mm (1.2") gypsum board
(vi) for buildings with exterior walls supporting a maximum of two floors and a roof

3.4 Fire Endurance Requirements

In order to qualify for specific fire-resistance ratings the NASCOR II R20 wall system, because of its unconventional manner of construction, must be tested for whatever rating is required with specific sheathing materials in place (ie- clad with 15.9mm Type X gypsum board). The following sections of the Uniform Building Code make some specific requirements:

(i) the foam plastic insulation (such as expanded polystyrene) must have a flame-spread rating of not more than 75 and a smoke-developed rating of not more than 450 when tested in accordance with UBC Standard No. 42-1.

(ii) The fire-resistance rating of an assembly must be tested in accordance with UBC Standard No. 43-1 (as per section 4302).

3.5 Test Objectives

The NASCOR II R20 wall system is unconventional in many ways, especially the structural loadbearing components. It would be very difficult to predict the behaviour of this system by conventional engineering analysis. Therefore the ICBO Evaluation Service Inc. requires such systems to undergo structural testing. Through analysis of structural test data, load tables can be produced. Also, all components of the wall system such as fasteners, adhesive, lumber, etc. must be tested and compared to conventional practices. As a result of all the above testing and analysis, ICBO can conduct an evaluation to see that the wall system meets the applicable requirements of the Uniform Building Code and can produce an Evaluation Report which can accurately and safely predict the performance of the NASCOR II R20 wall system.

The objective of conducting a fire resistance test on the NASCOR II R20 wall system is to enable Cano Structures to expand the market for the wall system into commercial and multi-family residential projects where a fire resistance rating may be required for the exterior walls.

4.0 TESTING PROCEDURE

To achieve the test objectives stated in the previous section, structural testing procedures as outlined in the "ICBO Acceptance Criteria for Sandwich Panels" were followed. The ICBO requires that building components and assemblies which are being submitted for its evaluation be tested by an "approved" testing laboratory. One such laboratory is Warnock Hersey Professional Services Ltd. of Coquitlam, B.C. which was engaged to undertake all of the required work.

The NASCOR II R20 wall system was subjected to structural and material testing to provide data for use by the ICBO Evaluation Service Inc. in its product evaluation process. A derivation of the wall panel system was further tested to determine its fire resistance. This was done in pursuit of additional ICBO certification for an expanded market. The test procedures are described below and the test results are discussed in Section 5.0. Appendices C through E contain the Warnock Hersey laboratory test reports.

The ICBO Acceptance Criteria for Sandwich Panels requires three separate test procedures to be performed on wall panels - an axial load test, a transverse load test, and a racking load test. Each individual test involved three wall panels so a total of nine NASCOR II R20 wall panels were tested. Two additional wall panels were also tested at a greater height in the transverse load test program. Six of the test panels measured 1220 x 2440mm (4'x8'), three measured 2440 x 2440mm (8'x8'), and the two additional panels tested in the transverse load test measured 1220 x 3660mm (4'x12'). Later on in the ICBO evaluation process, the ICBO also required that four additional panels be tested

under axial load. These panels measured 2440 x 3048mm (4'x10'). All wall panels were 140mm (5 1/2") thick and were constructed with columns spaced at 600mm (24") on center.

The NASCOR II R20 exterior wall system differs from conventional exterior wall systems due to its use of wood screws rather than nails and the use of a PVA adhesive instead of a Type 2 Class 2 adhesive generally specified by the Uniform Building Code. Consequently ICBO requested comparative testing of the screws and the adhesive. This is described below.

4.1 Transverse Load Test

Three 1220 x 2440mm (4'x8') NASCOR II R20 wall panels were initially tested. Each panel was placed horizontally in the testing apparatus shown in Appendix C. The resultant span was 2286mm (7'-6") when mounted. The transverse loading was applied vertically to the quarter points of each horizontally positioned wall panel by two hydraulically controlled steel plates. At each increment of load, the mid-span deflection was measured using dial indicators on the top and bottom of the wall panel.

Additional transverse load tests were conducted on two 1220 x 3658mm (4'x12') NASCOR II R20 wall panels in exactly the same manner as described above.

4.2 Axial Load Test

Initially, three 1220 x 2440 mm (4'x8') NASCOR II R20 wall panels were tested in a standard test frame as shown in Appendix C. The test panels were mounted vertically in the testing apparatus and a load was applied to the top of the panel by meams of a hydraulically controlled steel I-beam. As per ASTM E72-80 requirements, the centroid of the vertical load was applied at an eccentricity of one third the wall panel thickness, 47 mm (1 13/16"), from the interior face of the wall panel. At each load increment, the deflection at the center of the test panel was measured and recorded with the corresponding lead. Other deflections measured were the shortening of the panel under load and the expansion of the test panel at each vertical edge.

Four additional axial load tests were performed on NASCOR II R20 wall panels measuring 1220 x 3048mm (4'x10') to establish the structural capacity of walls over 2440mm (8') high.

4.3 Racking Load Test

Three 2440x 2440mm (8'x8') NASCOR II R20 wall panels were tested in the framework as shown in Appendix C. All panels were clad with 12.9mm (1/2") gypsum board sheathing on the interior side and were mounted vertically in the test apparatus. The bottom of the wall panel was anchored to the test frame and a load was applied to the top corner of the wall panel by a hydraulic ram. The load was applied in increments and the corresponding deflection measured at the opposite end of the test panel.

4.4 Screw Connector Test

Most wall panel systems are constructed using nail connectors, and it was therefore necessary to demonstrate that the "Lo-Root" 76mm (3") and 125mm (5") #10 screws used by Cano in its factory assembly of individual components into wall units met or exceeded the shear and holding properties of the more widely used 89mm (3 1/2") 16d nail. To this end, shear and pull-out tests of the two screws were conducted according to ASTM Standard D1761.

4.5 Adhesive Test

The wall panels were constructed with a PVA glue and tested as such. However, the ICBO would only accept a Type 2 Class 2 adhesive (a category selected from their Acceptance Criteria for Sandwich Panel Adhesives) the requirements of which the PVA does not meet. Therefore another adhesive was selected for use in the U.S.A. which meets their criteria (MorAd 336 by Morton Thiokol). Since all testing was done on wall panels constructed with PVA glue, Cano had to prove that the MorAd 336 was as good or better than PVA glue used in the test panels.

4.6 One Hour Fire-Resistance Test

A NASCOR II R20 wall panel with modified R20 Dowelled Columns at 610mm (24"o.c.) and measuring 2743mm (9') high by 4267mm (14') long was submitted for a fire endurance test to determine whether it would achieve a one hour fire-resistance rating. Testing was done in accordance with CSA Standard CAN4-S101, "Standard for Fire Endurance Testing of Building Components". The ICBO approved procedure, ASTM E119-83, is essentially the same so the results would be entirely acceptable to the ICBO. The wall panel was clad with one layer of 15.9mm (5/8") Type X gypsum board on each face.

The NASCOR II R20 wall panel was mounted in a test frame and subjected to flame on one side originating from a furnace with nozzles at 150mm (6") on center. The wall panel was also loaded with a vertical load of 29 kN/m (2000 plf). Temperature gain and wall deflection were measured throughout the test period. The test lasts as long as the wall panel maintains the load or for one hour, whichever comes first.

5.0 DISCUSSION OF TEST RESULTS

5.1 Transverse Load Test

The transverse load test results were plotted on a graph of load versus deflection. The stiffness of the panels (the EI values) were determined using the lower, stiffer portion of the curves up to a deflection limit of L/180 and L/240. The upper portions of the curves were not used in the stiffness calculations because the wall system would never be designed to go beyond the deflection limit of L/240. The average stiffness value (EI value) of the individual test panel columns was calculated to be 7.58×10^6 lbs-in^2. A conventional 38 x 89mm (2x4) wood stud has an EI value of 6.53×10^6 lbs-in^2. Both EI values are based on S-P-F #2 grade lumber. It can therefore be safely concluded that the NASCOR II R20 column is equivalent to or stiffer in bending than a conventional 38 x 89mm (2x4) wood stud.

5.2 Axial Load Test

The axial load test results showed the axial load capacity of the individual columns of the NASCOR II R20 wall panels have more than twice the capacity of a single conventional 38 x 89mm (2x4) wood stud. This is to be expected since a NASCOR II R20 column is composed of two 38 x 89mm (2x4) wood members. The tests showed that with a safety factor of 3, the columns would support an axial load of 2730 lbs. The actual maximum allowable load is only 2570 lbs. as that represents the maximum allowable compression load permitted perpendicular to the grain in the S-P-F top and bottom plates.

5.3 Racking Load Test

The racking load test was conducted on NASCOR II R20 wall panels clad with one layer of 12.9mm (1/2") gypsum board sheathing on the interior side. The wall panels were tested with an interior sheathing because the interiors of most homes are finished with 12.9mm (1/2") gypsum board and 12.9mm (1/2") gypsum board is an approved thermal barrier (which is required over polystyrene insulation as per the Uniform Building Code). The results obtained from a wall panel tested with gypsum board sheathing would reflect very realistic and usable results. The test results indicated that the maximum allowable racking load for a NASCOR II R20 wall clad on the interior face with 12.9mm (1/2") gypsum board is 905 N/m (62lbs/ft) with a safety factor of three.

5.4 Screw Connector Test

The test results, as reported in Appendix E, indicate that the "Lo-Root" 76mm (3") and 125mm (5") screws perform comparably to the 89mm (3 1/2") 16d nail they were replacing; consequently, the use of screws in the NASCOR II R20 assembly was considered acceptable.

5.5 Adhesive Test

Comparative shear tests were carried out on 102mm (4") long specimens of the NASCOR II R20 columns assembled with the PVA adhesive and the urethane adhesive (MorAd 336). Testing indicated that the MorAd 336 required approximately 12% higher loads to achieve failure as compared to the PVA adhesive; consequently, the proposed assembly to be used in the U.S. would exceed the structural integrity of the Canadian panels which were tested and found acceptable (see Appendix E).

5.6 Fire Endurance Test

Previous fire endurance tests on the NASCOR II R20 wall system established a two hour and a one hour non-loadbearing fire resistance rating.

In fire situations the polystyrene core of the columns breaks down and slowly melts away. When this happens the structural integrity of the column is lost since the 38x89mm (2x4) wood members then act independently of each other. It was suggested that the two 38x89mm (2x4) wood member components of the NASCOR II R20 column be linked together by something such as hardwood dowels.

As shown in the results of Warnock Hersey's fire test (Appendix D), the dowels in the modified NASCOR II R20 columns failed to contribute to the ability of the columns to support a vertical load under fire conditions. Charring at the dowel - wood member interface resulted in the free and independent movement of the column's two wood members and this led to eventual failure of the wall test panel before the one hour time requirement was achieved. Additional testing is planned in the future to attempt to achieve the one hour loadbearing fire resistance rating.

6.0 PRODUCT ACCEPTANCE BY ICBO

ICBO product acceptance results in the issuance of a material evaluation report. Such a report can be used to boost customer confidence in the product and allows the product to be used in those areas where construction is regulated by the Uniform Building Code.

After the necessary information and test data were submitted to ICBO, it issued "ICBO Evaluation Report No. 4491" (see Appendix F) which covered the NASCOR II R20 wall system. The report describes the system, its usage and limitations. It includes illustrations of the typical assemblies, confirms compliance with the 1985 Uniform Building Code, outlines on-site installation procedures, and describes how the system is to be identified.

7.0 CONCLUSION

A number of tests were performed on the NASCOR II R20 wall system to establish their performance under various loading conditions and to confirm compliance with the Uniform Building Code (as published by ICBO). Structural tests were performed on a number of NASCOR II R20 wall panels to establish their structural capacity. Tests were also conducted on the screw fasteners and adhesives used in the wall system to evaluate their performance. Warnock Hersey Professional Services Ltd., who performed all the testing, concluded that the NASCOR II R20 wall system is equivalent to and slightly better than conventional 38x89mm (2x4) wood stud wall systems in structural capacity. In fact, the axial load tests determined that a NASCOR II R20 column has more than twice the allowable capacity of a single 38x89 (2x4) wood stud.

The testing of the NASCOR II R20 wall system confirmed all of Cano Structures' expectations regarding the structural performance of the wall system and resulted in ICBO acceptance of the product, as confirmed in ICBO Evaluation Service Inc. Evaluation Report # 4491. With this product acceptance, Cano Structures can market the NASCOR II R20 wall system in the United States.

Efforts to achieve a new one hour loadbearing fire resistance rating for the wall system utilizing a revised column detail were not successful. Work is continuing to develop a new and more cost-effective method, however, in the interim, users can employ the existing ratings for the wall system.

APPENDIX A

ICBO ACCEPTANCE CRITERIA FOR

SANDWICH PANELS

International Conference of Building Officials
Research Committee

ACCEPTANCE CRITERIA FOR SANDWICH PANELS

(July, 1974)

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1. SCOPE: The intent of this Standard is to provide uniform acceptance criteria for sandwich panel construction except where specifically regulated by the Uniform Building Code. Alternate procedures which comply with the intent of this Standard will be considered.

1.1 Panel Justification Options:

1.1.1 Panels may be justified by load tests as described in Paragraph 4. Justification by this method limits their use to sizes and materials used in the tests. Allowable loads determined may be used for shorter spans or heights but extrapolation is not permitted.

1.1.2 Panels may be justified by a rational analysis based on allowable stresses developed as described in Paragraph 5.

1.2 All testing must be done by an approved testing agency. Tests may be conducted by the proponent provided all phases are monitored by a qualified independent observer, with no financial interest, as determined by the Research Committee prior to testing.

1.2.1 Testing procedures must include proper justification that test specimens comply with specifications submitted as a part of the research report application. Fabrication must be observed by a qualified representative of the testing agency.

1.2.2 Test reports must be complete, including panel description, test set-ups, manner of testing, observations, all test readings, etc. Test summaries are not acceptable.

1.3 Factors of Safety:

1.3.1 Factors of safety are set forth in subsequent sections and are based on the materials involved, test procedure, panel deformation, and variation of results.

1.3.2 Allowable values developed under Paragraph 1.3.1 are not subject to increases due to duration of loading unless specifically allowed. This includes wind and seismic forces.

1.3.3 Where loading conditions result in several modes of related stressing, the sum of the ratios of actual loads over allowable loads shall not exceed one. Wind on a bearing wall is one example of requiring this consideration.

1.4 Supplementary information may be included in the research report, provided it relates to the Uniform Building Code, and is properly justified. This includes sound transmission insulation as specified in Chapter 35 of the Uniform Building Code Appendix.*

2. PANEL DESCRIPTION: The panel description is to include the following information:

2.1 Thickness, width and length for each panel type.

2.2 Panel Facing Material:

2.2.1 The material must be acceptable under a current Research Recommendation, a National Product Standard, the Uniform Building Code, or be justified to the satisfaction of the Research Committee. The material must be clearly identified to determine compliance.

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2.2.2 Panel skins classified as weather-exposed surfaces under Section 424 of the Uniform Building Code must comply as a weather-resistive barrier.

2.2.3 Panel skins subject to axial or racking shear loads must have approved values for fasteners. Where no values are recognized by the Research Committee, fastener tests must be conducted for both shear and nail-head pull-through at the minimum edge distances contemplated. Allowable values for fasteners may control allowable panel loads when they are more restrictive than the panel test values. Specimens shall be conditioned and where skins are subject to wetting, shall be additionally tested in that manner. Sections 41 through 67 of ASTM D-1037 serve as a guide for test procedures which must be approved prior to testing.

2.2.4 Panel facings must have flame-spread classifications, smoke densities and products of combustion as specified in Section 4202 (b) or Section 5205 of the Code. When these characteristics are affected by the core material of the panel, the combined section shall be tested when deemed necessary by the Research Committee.

2.3 Panel Cores:

2.3.1 Honeycomb specifications are to include a detailed description or illustration noting the thickness, cell size, kraft paper weight or metal thickness, direction of the paper or metal ribbon, percent impregnation of materials, etc.

2.3.2 Foamed plastic specifications are to include the density, thickness, whether it is a preformed slab, frothed or expanded, foam manufacturer and the type, catalog number, etc. The position of the panel during the frothing or pouring operation is to be specified.

2.3.3 Other core materials with specifications and descriptions will be considered.

2.3.4 Any adhesives used must comply with U.B.C. Standard No. 25-19 or the Research Committee Standard for Sandwich Panel Adhesives. Adhesive specifications are to include the type, class, thickness of application, number of coats, assembly instructions, etc.

2.3.5 When the core material does not completely fill the portion between panel facings, voids must be detailed or properly described. Voids formed by honeycomb cells are not regulated by this subsection. The method used to maintain voids during foaming or bonding must be described.

2.3.6 Core materials classified as noncombustible must be justified under Section 415 of the Code. Combustible core materials, including plastic, must have a minimum Class III flame-spread classification (76-225) and smoke density not exceeding 450 when tested under U.B.C. Standard No. 42-1 in the thickness intended for use. Products of combustion shall be no more toxic than the burning of untreated wood under similar conditions.

2.4 Wood plates, splines, studs, blocking, etc., are to have wood species, grades, preservative treatments and maximum moisture contents at time of panel manufacture specified. Lumber must be stress graded or stress rated material. Lumber bonded to panel facings with adhesives must have a moisture content not in excess of that recommended by the adhesive manufacturer, between 7 and 16 percent, or not exceeding a difference of 5 percent between the two materials bonded, whichever is more restrictive. Complete cross-sectional details, dimensions and sectional properties of the members are required.

2.5 Connections must be detailed or adequately described. Fasteners must be properly specified including size, length and location.

2.6 Details for door and window openings must be provided to clarify the manner of supporting axial, transverse and/or racking shear loads. This includes the method of resisting wind loads at door and window jambs.

3. MISCELLANEOUS PANEL INFORMATION:

3.1 No substitution of materials is allowed unless approved by the Research Committee.

3.2 Field cutting of wall openings is not allowed unless specific openings or design parameters are approved by the Research Committee.

3.3 Test loads and manner of application on full structures shall be specified by the Research Committee when design parameters for the full structure cannot be readily determined by accepted engineering principles.

3.4 Wall panel facings and top facings of floor and roof panels shall have sufficient strength to resist concentrated loads and prevent damage to the core material under loads to which they may be subjected.

3.5 Plumbing and waste lines may extend at right angles through the wall panels but are not permitted vertically within the core. Lines shall not interrupt splines or panel plates unless specifically approved by the Research Committee.

3.6 Electrical outlet boxes and raceways may be installed in the panels during fabrication at predetermined locations only. Electrical systems are limited to a single 1-inch maximum (outside of diameter) vertical raceway at a minimum of 4 feet on center, which is shop installed with no more than three outlet box openings 4 inches by 4 inches in size. Two ½-inch vertical raceways may be substituted for the single 1-inch raceway provided they are maintained parallel and within 2 inches of each other.

3.6.1 Voids other than those specified in Paragraph 3.6 will be permitted for field or shop installation of electrical wiring provided the voids were in the panels tested. See Paragraph 3.2 for field cut openings.

3.6.2 Where electrical raceways interrupt or reduce the cross section of wall plates, a method of strengthening the plate at that point for both lateral and plate axial loads must be developed, detailed and submitted for evaluation.

3.7 Flashing and other weatherproofing details are required for panel joints, wall openings, etc.

4. PANEL LOAD TEST OPTION:

4.1 In lieu of determining structural and mechanical properties of panel components for rational design purposes, load tests may be conducted to determine reasonable ultimate values to which factors of safety are applied.

4.2 General:

4.2.1 The tests are to be conducted as set forth under Paragraph 1.2.

4.2.2 Except for the impact test, three tests of each type are required with none varying more than 15 percent from the average of the three, unless the lowest test value is used. The average result based on a minimum of five tests may be used regardless of the variations. The results of two tests may be used when the higher value does not exceed the lower value by more than 5 percent and the lower value is used with the required factors of safety.

4.2.3 Where tests are not conducted to failure, the highest load achieved for each test will be assumed as ultimate.

4.2.4 Factors of safety are dependent on the consistency of materials, the range of test results and the load deformation characteristics of the panel. Generally, a minimum factor of safety of three is applied to the ultimate load based on the average of three tests. Lower factors of safety may be assigned to panels or systems employing steel or aluminum having consistent physical properties.

4.2.5 Allowable loads will be limited by established fastener values or deflection limitations if lower than values from panel loading tests.

4.2.6 Splines or stiffeners, when utilized along the edges of the panel in tests, shall be only that portion of the typical construction relative to the panel being tested and not supplemented by adjacent panel spline areas.

4.2.7 Load tests shall be conducted with connection details intended in field installations. The testing agency is to report any variations.

4.3 Transverse Load Tests — Wall Panels:

4.3.1 With the designed wind load imposed, exterior wall panel deflections shall not exceed $L/180$. Positive and negative pressure conditions shall be considered. Wall panels with different facing materials on opposite faces must be tested for loads acting both inwardly and outwardly where there is a question of the most critical direction.

4.3.2 With a 5-pound per square foot horizontal loading imposed, interior wall panel deflections shall not exceed $L/120$ of the span for flexible skin material such as metal, plywood, particleboard and gypsum wallboard. A deflection limitation of $L/240$ of the span is required for brittle skin materials such as plaster.

4.3.3 All wall panels shall be loaded in increments to failure with deflections taken to obtain deflection and set characteristics. Where preloading is applied, the loading, deflection and recov-

ery shall be noted. The amount of preloading shall not exceed 10 percent of the final allowable load unless approved by the Research Committee.

4.3.4 Transverse load tests on panels having window or door openings are required unless subject to rational analysis. Load application must be done in a manner that reflects field loading conditions.

4.4 Axial Load Tests — Wall Panels:

4.4.1 Load-bearing wall panels must support an axial loading applied with an eccentricity of one-sixth the panel thickness to the interior or towards the weaker facing material of an interior panel.

4.4.2 The test panels must have wall sill and cap plate details with connections matching the proposed field installation. Axial loads must be applied uniformly or at the anticipated spacing of the floor or roof framing.

4.4.3 The bottom edges of the panel facing material shall be held at least ¾ inch above the base of the sill plate to insure no direct bearing of the facings against test equipment framing. Panels may be inverted during testing if desired to meet the above loading requirements. If, due to deflection, the ¾-inch panel base clearance is dissipated, the load at this point shall be specified.

4.4.4 Lintel sections shall meet the deflection criteria of Table No. 23-D of the Code.

4.4.5 All wall panels shall be loaded in increments to failure with deflections taken to obtain deflection and set characteristics. Where preloading is applied, the loading, deflection and recovery shall be noted. The amount of preloading shall not exceed 10 percent of the final allowable load unless approved by the Research Committee.

4.5 Racking Shear Tests — Wall Panels:

4.5.1 Racking shear tests in accordance with ASTM E-72, as amended by this Standard, are required for shear walls which resist wind and seismic forces.

4.5.2 The allowable shear load is determined from the racking load at which a net horizontal deflection of ½ inch occurs, the ultimate load divided by a factor of safety determined in accordance with Paragraph 4.2.4, or the allowable fastener loads, whichever is the lower. The test panel must be constructed and installed as intended in the field, including connections. Reference is also made to Paragraph 4.2.6 of this Standard.

In reference to Paragraph 4.5.7, hold-down rods may be used provided allowable net horizontal deflections are reduced to ⅛ inch.

4.5.3 The "stop" detailed in the ASTM E-72 procedure for installation against the toe of the test panel should be located in such a manner that reactive forces are imposed against the end of the sill plate, and clear of the panel spline and facing material.

4.5.4 The bottom edges of the panel facing material must be held at least ¾ inch above the base of the sill plate to insure against direct vertical bearing or frictional shear resistance of the facings against test equipment framing. The testing laboratory shall indicate the load at which the ¾-inch panel base clearance from the test frame is dissipated.

4.5.5 The panel top horizontal timber suggested for the test panel in the ASTM E-72 sketch shall not be used. The racking shear load should be applied directly against the typical wall panel top plate member or members that duplicate actual field construction unless otherwise approved.

4.5.6 All wall panels shall be loaded in increments to failure with deflections taken to obtain deflection and set characteristics. Where preloading is applied, the loading, deflection and recovery shall be noted. The amount of preloading shall not exceed 10 percent of the final allowable load unless approved by the Research Committee.

4.5.7 The standard racking shear hold-down rods shall not be used. Panel elements and connections to the base shall resist the uplift forces. See Paragraph 4.5.2 for alternate.

4.6 Impact Tests:

4.6.1 Impact tests shall be conducted when required by the Research Committee.

4.6.2 The tests are to be conducted in accordance with ASTM E-72 Equipment and Principles for "Impact Load Specimen Horizontal," to determine the point at which the panel facing becomes deformed or delaminated from the core material. The test utilizes a 60-pound sand bag drop. Full size sandwich panels, usually 4 by 8 feet in size, are cut in two, forming two 4 by 4-foot test panels. The half-panels are supported along the two sides and end remaining from the full size panel, leaving the cut edge unsupported. The test panels are restrained over their supports with a spring-loaded frame to reduce "jump" after impact. The amount of restraint shall be no less than 10 times the weight of the half-panel. The point of impact for both tests shall be the geometric center of the half-panel face, except when a spline or rib occurs at that section. When this occurs, the target shall be moved to impact midway between any splines or ribs.

4.6.3 The 60-pound standard sand bag is dropped from a height of 7 feet a total of four times. The target area is then cut into 12-inch squares, cornered on the middle of the impact area to determine if delamination has occurred. The second half-panel is tested and inspected in the same manner. Should no delamination or deformation be found in either panel at the point of impact or elsewhere along the cut edge of the panel, the panel facing is considered satisfactory with the specific core material.

4.6.4 If one of the panels fails, a total of four half-panels shall be tested in the same manner. Three of the four panels shall not delaminate from the facing material to be considered satisfactory.

4.6.5 Impact tests on panels having single or double curvature such as in shells or domes are to be tested with the convex surface upward. The panels shall closely approximate the 4 by 4-foot flat test panel. Longer spans are not permitted due to their greater energy absorption characteristics. Tests shall otherwise be the same as for the flat panels.

4.6.6 Panels having metallic facings which are excessively deformed by the sand bag without rebounding to their original position are considered unsatisfactory.

4.6.7 When there is a question of brittle panel facings, supplementary tests may be necessary, as determined by the Research Committee.

4.7 Transverse Load Tests — Roof and Floor Panels:

4.7.1 Allowable loads for roof and floor panels are determined under Paragraphs 4.2.2 to 4.2.7. Panels shall comply with the deflection requirement of Table No. 23-C of the Code. Additionally, roof panels shall be limited to a maximum deflection of the span divided by 180 when subjected to roof live load or snow load, whichever governs.

4.7.2 Deflection readings are to be taken at mid-span at each edge and the center of the panel. Panels tested over a double span are to have the same three deflection readings taken at the expected maximum deflection point based on analysis.

4.7.3 Roof panels having different facing materials on the same panel are to be tested so each facing material will be in compression and tension. Floor panels or panels tested on a two span condition need not be tested in both directions.

4.7.4 The "Bag Method," vacuum chamber or a uniform loading of known unit weights shall be used for transverse tests.

4.8 Density-Water Absorption Tests — Foamed Plastic Core Material:

4.8.1 The density and water absorption characteristics of foamed-in-place cores are to be determined from the load test panels after completion of tests. The test procedure in ASTM C-272 is to be utilized with the following revisions.

4.8.2 The conditioning temperature of Section 4.1.1 of ASTM C-272 is to be increased to 158 degrees Fahrenheit, plus or minus 5 degrees, in lieu of the specified 122 degrees Fahrenheit.

4.8.3 Representative specimens shall be taken from panels that have been adequately cured. The report shall specify curing procedures. Panels indicating obvious discrepancies in load test results due to insufficient curing shall not be used.

4.8.4 Six specimens shall be taken from a representative panel of each set subjected to the transverse loading test.

4.8.5 The density-water absorption specimens are to be obtained as follows, assuming a 4 by 8-foot panel. The previously tested full size solid panels are cut across the 4-foot dimension 4 to 8 inches from each end and then longitudinally down the middle of the remaining center portion. Three-inch square samples are cut from each outside quarter point of the end sections and one sample cut from each of the two remaining center portions, totaling six samples from each panel. The sam-

ples are to be cut a minimum of 1 inch away from any splines. A sketch is to be included in the laboratory report locating and numbering the location of each specimen.

4.8.6 The 3-inch square samples are cut to maintain the entire panel thickness including facings. The volumetric dimensions are measured "as received" and after removal of facings in accordance with Paragraph 3 of ASTM C-272. The density and water absorption tests are conducted in accordance with ASTM C-272 with the facings removed. Care must be taken to assure that minimal core material is removed. Dimensions are taken after the first oven curing and after each conditioning of the absorption tests. After the final oven drying, the specimen dimensions are recorded.

4.8.7 The two-hour immersion linear measurements required by ASTM C-272 may be omitted.

4.8.8 Foam density variations for the different sample locations may not vary by more than 25 percent from any other sample taken from the same panel based on the lower value of the two being compared.

4.8.9 Subsequent density-water absorption tests in conjunction with quality control or re-examinations by the Research Committee must follow the same test procedure as used initially to assure the validity of comparing results.

4.9 Density Tests — Preformed Foamed Plastic Core Material: Panels having preformed foam cores bonded in place with an adhesive are to have density tests conducted in accordance with ASTM C-271. Two samples are to be cut from one of each set of panels subjected to the axial, transverse loading and racking shear tests respectively. The samples are to have the facing material removed, together with any adhesive impregnated core material prior to the density determination. The average density values are to be based on a minimum of six samples. Panels with window and door openings are to have their cores treated in a similar manner.

4.10 Density, shear and other tests for other than foamed plastic cores shall be determined by the Research Committee.

4.11 Substantial differences in coefficients of expansion between core and facing materials require justification that this will not be detrimental to the panel integrity. Testing under ASTM C-393 after aging under Cycle B, ASTM C-481 shall be considered sufficient to determine this quality. Heated dry air shall be increased to 182 degrees Fahrenheit plus or minus 2 degrees in Cycle B.

4.12 Substantial differences in temperature between facings of a panel with high coefficients of expansion require justification that this will not be detrimental to the panel integrity.

5. PANEL ANALYSIS OPTION:

5.1 To provide flexibility in panel size with minimal full scale panel testing, the characteristics and allowable stresses for each material used in the panels may be determined to permit a rational analysis. Supplemental tests on actual panels will be necessary only to verify design assumptions and criteria.

5.2 Each facing material, unless allowable working stresses are established in the Uniform Building Code or are acceptable to the Research Committee, is to have the following characteristics determined by representative tests. Waiver of any of the following characteristics must be with the concurrence of the Research Committee.

5.2.1 Modulus of elasticity (bending).

5.2.2 Tension parallel to surface.

5.2.3 Tension perpendicular to surface.

5.2.4 Modulus of rupture.

5.2.5 Compression parallel to surface.

5.2.6 Shear parallel to surface.

5.2.7 Density.

5.2.8 Shear modulus.

5.2.9 Fastener values in shear and, where applicable, nail or screw head pull through for each facing material as set forth in Paragraph 2.2.3.

5.3 Panel cores shall have the following characteristics established:

5.3.1 Modulus of elasticity (bending).

5.3.2 Tension perpendicular to surface.

5.3.3 Compression perpendicular to surface.

5.3.4 Shear parallel to surface.

5.3.5 Shear modulus (in each direction for honeycomb and foam materials).

5.3.6 Density for foams and related products, core size, weight and degree of impregnation for paper honeycomb or the standard identification specification for aluminum or light gauge steel honeycomb.

5.4 Tests to determine the facing and core characteristics are as follows:

5.4.1 Tension – ASTM C-297 "Tension Test of Flat Sandwich Construction in Flatwise Plane" for core material, and ASTM D-1037 "Evaluating the Properties of Wood Base Fiber and Particle Panel Materials," Sections 20 to 26 and 27 to 32 for facing material.

5.4.2 Compression – ASTM D-1037 "Evaluating the Properties of Wood Base Fiber and Particle Panel Materials," Sections 104 to 110, Procedure 3 for facing material.

5.4.3 Shear and Shear Modulus – ASTM C-273 "Shear Test in Flatwise Plane of Flat Sandwich Construction or Sandwich Cores," for core and facing material by tension tests.

5.4.4 Modulus of Rupture – ASTM C-393 "Flexure Tests of Flat Sandwich Construction," for evaluation of facing materials in sandwich construction.

5.4.5 Density – Paragraph 4.8 for frothed or poured-in-place foams and ASTM C-271 "Density of Core Materials for Structural Sandwich Constructions" for slab type foams bonded in place in the panels.

5.4.6 Modulus of Elasticity – ASTM C-393 "Flexure Test of Flat Sandwich Constructions" for facing materials in sandwich construction.

5.4.7 Fastener Values – ASTM D-1037 "Evaluating the Properties of Wood-Base Fiber and Particle Panel Materials," Sections 41 to 67.

5.4.8 Compression – ASTM C-365 "Flatwise Compressive Strength of Sandwich Cores," Method "B" for core material.

5.5 Adhesives are to comply with U.B.C. Standard No. 25-19 or the Research Committee Standard for Sandwich Panel Adhesives.

5.6 Racking shear loads must be determined under Paragraph 4.5. Density and water absorption tests on six specimens from one panel in conformance with Section 4.8 are required for foamed panels.

5.7 Coefficients of expansion of core and facing materials shall be investigated as noted in Paragraphs 4.11 and 4.12.

6. ADDITIONAL FABRICATOR QUALIFICATION PROCEDURES: The following procedures are necessary for recognition of supplementary fabricating facilities:

6.1 A qualified representative of an approved testing agency shall select at least three panels at random of each panel core type. The panels are to be permanently identified by the laboratory personnel and shipped to the testing agency facility.

6.2 Each of the three panels selected shall be subjected to a transverse load test in accordance with Section 4.3 or 4.7. The test results shall be no lower than 85 percent of the average original plant transverse test results.

6.3 For foamed-in-place cores, one panel is to be selected for each panel type and six density-water absorption specimens cut from the panel and tested in accordance with Sections 4.8 and 4.9. The density-water absorption test average shall be no lower than 85 percent of the original plant test average nor shall any specimen vary more than 25 percent in density from any other sample taken from the same panel, based on the lowest value.

6.4 The preformed core panel density shall agree with the original core density.

7. PANEL IDENTIFICATION: Panels shall bear the company name, research recommendation number and other information deemed necessary by the Research Committee. The identification must be visible after the panels are erected. Exterior panels must have the exterior face clearly identified.

8. QUALITY CONTROL: Quality control procedures with monitoring inspections by an approved inspection agency shall be developed for each fabrication facility based on the panel construction, application, volume of production, etc. The procedures shall be included in a quality control manual which must be developed jointly by the fabricator and inspection agency. Panel fabrication is not sanctioned until quality control procedures have been approved.

APPENDIX B

ICBO ACCEPTANCE CRITERIA FOR

SANDWICH PANEL ADHESIVES

International Conference of Building Officials
Research Committee

ACCEPTANCE CRITERIA FOR SANDWICH PANEL ADHESIVES

(July, 1974)

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1. SCOPE AND SUMMARY: The intent of this Standard is to provide acceptance criteria for sandwich panel adhesives that are not regulated by U.B.C. Standard No. 25-19. It is not intended to provide alternate adhesives for wood members regulated by U.B.C. Standards No. 25-10 and No. 25-18.

1.1 Establish minimum performance levels pertaining to moisture, temperature, accelerated aging, creep, oxidation or ozone (whichever is selected), mold, chemical reagents and compatibility.

1.2 The Standard provides the adhesive manufacturer with a means of recognition for his product as set forth in Paragraph 2. Recognition of an adhesive in a research recommendation, unrelated to any panel system, will provide basic information on the adhesive under conditions set forth in Paragraph 1.1, and additionally, as an option, shear and bond strengths with panel facing materials of the adhesive manufacturer's choice. In both instances, basic adhesive information must be determined by tests (Paragraphs 8.3 to 8.8) conducted with stable materials set forth in Paragraphs 5.1.1 to 5.1.4. The specific stable material or materials used should be representative of the use intended. Basic tests on Douglas fir, as one example, would not be sufficient for a metal skin panel application. In all instances, creep tests may be waived for a Type I adhesive. See Test Tabulation, Figure No. 1, on page 5.

1.3 Recognition of specific panel skins with an adhesive requires that shear and bond strengths with the panel skin be determined, and adhesive compatibility with the skins be established. This includes fire-retardant or preservative treatments. Panel skin tests are conducted on specimens which are cured and conditioned in accordance with the panel manufacturer's recommendations. This must be compatible with recommendations of the adhesive manufacturer. Testing shall be as noted in Paragraphs 8.1.1 and 8.9. In conjunction with sandwich panel applications, the adhesive must be justified under Paragraphs 8.1.1, 8.1.2, and 8.9 to 8.11.

1.4 The Standard does not attempt to establish allowable values for sandwich panels. This is regulated by the companion Acceptance Standard for Sandwich Panels dated ~~July, 1974~~ 1977.

2. ADHESIVE CLASSIFICATION: The adhesives shall be classified in accordance with their use and characteristics as follows:

2.1 Type I: An adhesive for use in wall panels subject only to short term transverse or racking shear loads resulting from wind or seismic forces.

2.1.1 Class 1: An adhesive with low resistance to moisture and creep. Acceptable for interior nonbearing partitions, etc.

2.1.2 Class 2: An adhesive with high moisture resistance and low creep resistance such as exterior nonbearing walls and other locations where high moisture resistance is necessary.

2.2 Type II: An adhesive for use in panels supporting loads other than the panel weight.

2.2.1 Class 1: An adhesive with low moisture resistance and high creep resistance such as interior bearing walls, exclusive of those exposed to heavy moisture conditions.

2.2.2 Class 2: An adhesive with high moisture and high creep resistance.

3. BASIC INFORMATION: The following basic information shall be submitted:

3.1 Recommended moisture content of material, where applicable, at the time of gluing.

3.2 Complete mixing instructions for the adhesive.

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3.3 Application instructions, including the rate of spread, thickness of wet and dry film, number of coats, whether to be applied to one or both contact surfaces, conditions for drying where more than one coat is required, weight per square foot in spray applications, etc.

3.4 Assembly conditions, including room temperature, humidity and time limitations.

3.5 Curing conditions, including pressure, time under pressure, temperature of the assembly under pressure, etc. Limiting temperature should be clarified as that of the glue line or air.

3.6 Pot life, storage temperature, maximum storage life, permitted fillers, if any, and their maximum quantities.

3.7 Method of packaging and identification of components.

4. REPORT OF TESTS:

4.1 Tests are to be conducted and reported by an approved testing agency. Tests may be performed in the laboratory of the proponent, provided the selection of materials, preparation of specimens, conditioning, accelerated aging and actual tests are observed, recorded and reported by a qualified individual acceptable to the Research Committee.

4.2 The test reports must cover all aspects of the test program, including data in Paragraph 3. The test programs must be reported in accordance with the referenced ASTM Test Specification or as amended in this Standard. All results are to be reported in lieu of averages of several identical tests.

5. TEST SPECIMENS:

5.1 The basic tests for an adhesive require curing, conditioning and accelerated aging of specimens prior to testing. Stable materials specified in the following subsections shall be used.

5.1.1 Hard Maple blocks having a minimum specific gravity of 0.65 based on oven-dry weight and volume (see Appendix of ASTM D-905 for specific gravity measurement), straight grained, free of defects such as knots, bird's eye, short grain, decay and any unusual defects, are to be used for adhesives bonding assemblies by valence forces.

5.1.2 Clear, straight grain Douglas fir, Coast Region wood, having a specific gravity range between .45 and .55 based on oven-dry weight and volume, is to be used for adhesives bonding assemblies by mechanical adhesion (interlocking action).

5.1.3 Metals may be used. The specification, aluminum heat treatment number, etc., are to be reported, together with the required condition of the faying surface and any special treatment necessary before bonding.

5.1.4 Other materials require prior approval before tests are conducted.

5.2 The faying surfaces of the test specimens must be protected from contamination prior to the gluing operations. Wood specimens are to be surfaced within 24 hours prior to gluing and be at the equilibrium moisture content recommended by the adhesive manufacturer. In the absence of such a recommendation, the moisture content shall be from 10 to 12 percent, based on oven-dry weight. When the recommended spread of the moisture content between the two specimens being bonded is 6 percent or more, samples at the upper and lower limits are to be tested to determine any variation in strength.

5.3 The grain of wood specimens shall be parallel and perpendicular to the direction of the applied load in the shear and bond tests, respectively.

5.4 Test specimens for adhesive properties in shear, bond and creep shall be as follows:

5.4.1 Block shear test specimens are assembled in accordance with ASTM D-905, "Strength Properties of Adhesive Bonds in Shear by Compression Loading," Paragraphs 4.1, 4.2, 5 and 6, and Figures Nos. 2 and 3. The test specimens shall be Maple or Douglas fir, complying with Paragraphs 5.1.1 or 5.1.2. See Paragraph 5.5 for other facing materials. Wood blocks shall have the same specific gravity (0.04 maximum variation) and their bonded contact area determined by dimensions to the nearest .010 inch.

5.4.2 Bond strength specimens shall be Maple or Douglas fir as described in Paragraphs 5.1.1 and 5.1.2. Preparation shall conform to ASTM C-297 "Tension Tests of Flat Sandwich Construction in Flatwise Plane." The two elements of each specimen shall be 2 inches square and ¾ inch thick. The contact areas shall be based on dimensions to the nearest 0.01 inch. See Paragraph 5.7 for bond test specimen preparation for metal to metal and metal to wood evaluation tests. See Paragraph 5.5 for other facing materials to be tested.

5.5 Panel facing materials such as plywood, particleboard, hardboard, special wood panel products, gypsum wallboard, fiberboard, fiberglass, etc., are not considered stable enough to be subjected to the accelerated aging under Paragraph 7.

5.5.1 Test specimens are to be prepared for each of the facing materials for which the manufacturer desires recognition. The two halves of each test specimen may be bonded to a backing material of Maple or Douglas fir with an adhesive complying with U.B.C. Standard No. 25-19, to provide a net half specimen thickness of ¾ inch. The grain of the facing material, when evident, is to be oriented parallel to the direction of load application for the block shear tests and normal to the applied force for bond tests.

5.5.2 The two halves of each specimen are bonded so the faying surface is at the facing material under consideration. At the proponent's option, only one of the faying surfaces need be the laminating material under consideration. Precautions are necessary in selecting the test specimen thicknesses to avoid affecting the block shear test results in the standard test equipment.

5.5.3 The test specimens are bonded under the conditions in Paragraph 5.2 and then cut to the dimensions noted in ASTM D-905 for block shear tests and ASTM C-297 (using 2-inch square specimens) for bond tests. Contact area dimensions are determined to the nearest 0.01 inch.

5.6 Test specimens to evaluate creep characteristics are assembled in accordance with ASTM D-1002, "Test for Strength Properties of Adhesives in Shear by Tension Loading (Metal to Metal)." The test specimens are provided with the required holes set forth in ASTM D-2294. See Figure No. 2, page 6.

5.6.1 As an alternate when the adhesive is designed for bonding wood to wood, the specimens may be a pair of 1-inch wide by 1-inch long by ¼-inch thick pieces of Maple or Douglas fir, each bonded to a No. 16 gauge metal strip. Wood shall comply with Paragraph 5.1.1 or 5.1.2. The adhesive bonding the wood to metal must be one that is unaffected by test conditions and not subject to creep. Adhesives recognized under U.B.C. Standard No. 25-19 are considered acceptable. See Figure No. 2 for construction of the test specimens.

5.6.1.1 The face of each wood piece shall be surfaced, unsanded, free of dust, straight grain, free from defects including knots, bird's eye (for Maple), short grain, decay and any unusual discolorations within the shearing area. The grain direction is to be parallel to the direction of pull. Moisture content is to comply with Paragraph 5.2.

5.6.1.2 The wood to wood test specimens shall have the same wood specific gravity (maximum 0.04 variation). The wood portion of each sub-assembly is coated with the adhesive in accordance with the manufacturer's instructions and brought into full contact. Pressure and heat, when specified, shall be applied for the required time period. Excess adhesive is removed from all edges prior to adhesive setting.

5.6.2 Where metal to wood shear specimens are tested, specimens shall be constructed as set forth in Figure No. 2.

5.7 Metal to metal shear test specimens are assembled as set forth in ASTM D-1002, with excess adhesive removed to assure a definite, uniform area of glue line. Metal to metal bond tests shall be conducted on 2-inch square specimens with sufficient metal plate thickness to accommodate the testing apparatus of ASTM C-297 or bonded to filler blocks of the required thickness to fit the apparatus. Metal to wood bond test specimens are prepared the same as for wood to wood specimens in Paragraph 5.4.2, except only one layer of wood is required between the two metal test blocks and using the same test adhesive on both faces of the wood.

5.8 The dry-film thickness and weight per square foot of each adhesive application must comply within 10 percent of that recommended by the manufacturer. This may be determined by placing a preweighed sheet of aluminum foil of a known area in a position where it will be simultaneously coated with the test specimens. Preweigh and calculate the dry adhesive deposited per unit area. From the known adhesive density, the dry-film thickness can be computed. The wet-film thickness may be determined by means of ASTM D-1212, "Measurement of Wet-Film Thickness of Organic Coatings," Method A or B.

5.9 In order to evaluate the effect of variations in the glue line thickness, six sets of five specimens each are to be assembled in accordance with Paragraph 5.6, 5.6.1.2 or 5.6.2. The six sets are to be divided into two groups of three sets each. The first group is to

be prepared using one-half of the recommended glue line thickness, and the second group prepared using one and one-half times the recommended glue line thickness. Two sets of specimens are to be conditioned in accordance with Paragraph 6 prior to testing as conditioned (control) only specimens and the other four sets accelerated aged in accordance with Paragraph 7. The total number of sets may be reduced to four when involving Class 1 adhesives, since testing under Paragraph 7.2 would not be required. The conditioned (control) specimen sets are to be one set from each group and the accelerated aged specimen sets are to be made up of the remaining sets from each group. Refer to Paragraph 8.6.5 for test procedures.

6. CONDITIONING: The test specimens are to be conditioned after curing in accordance with the adhesive manufacturer's recommendations prior to any testing or accelerated aging. If no specific conditioning procedure is recommended, the test specimens are to be subjected to an atmosphere having a relative humidity of 50 ± 2 percent and a temperature of 73 degrees ± 2 degrees Fahrenheit for a period of seven days, or until specimens reach equilibrium as indicated by no progressive change in weight. Specimens conditioned in accordance with this paragraph but not accelerated aged in accordance with Paragraph 7, are designated as conditioned (control) only specimens. The tabulation of the specimen weight and dimensional changes may be omitted.

7. ACCELERATED AGING:

7.1 Accelerated aging of "stable" specimens under cyclic laboratory aging conditions are to be conducted under ASTM D-1183-70, "Resistance of Adhesives to Cyclic Laboratory Aging Conditions." Class 1 adhesives may be aged under Procedure "A" for three cycles. Class 2 adhesives are aged under Procedure "C" for three cycles, except that the minus 70 degrees Fahrenheit temperature may be raised to minus 40 degrees Fahrenheit. After completion of accelerated aging procedures, the specimens are conditioned again in accordance with Paragraph 6 and immediately tested. The tabulation of the specimen weight and dimensional changes may be omitted for both procedures.

7.2 For Class 2 adhesives, five additional specimens are to be submerged in water at room temperature for 48 hours and then dried for eight hours at a temperature of 145 degrees ± 5 degrees Fahrenheit, followed by three cycles of soaking for 16 hours and then drying for eight hours under the same conditions of temperature. The specimens after exposure are to be conditioned again in accordance with Paragraph 6 prior to testing.

8. SPECIMEN TESTING:

8.1 The following tests are required to substantiate each adhesive in accordance with its Type and Class. Alternate tests or procedures require written approval prior to testing. The alternate methods must be substantiated, including reasons for not complying with this Standard and the equivalence of the alternate to the standard test method. The referenced test procedures refer to the latest ASTM procedures adopted, unless specified otherwise.

8.1.1 The adhesives are to be tested with each panel facing material for which recognition is desired. Sufficient test specimens are to be prepared and conditioned so that each panel facing material can be subjected to both the block shear test (Paragraph 8.3) and the bond test (Paragraph 8.5) in a conditioned (control) only state to determine their ultimate strength values. These values are for comparison with the test results derived from the hard Maple, Douglas fir, Coast Region or metal to metal test specimens, which are to be tested both in a conditioned (control) only state and an accelerated aged state.

8.1.2 When the coefficients of expansion for core and facing materials vary excessively, appropriate tests must be conducted to justify that differential movements of the elements will not be detrimental to the panel integrity. This is optional under this Standard but mandatory under the Acceptance Standard for Sandwich Panels.

8.2 The test report shall indicate the manner of failure for each specimen. This includes whether the adhesive, laminating or facing material failed and the percentage failure of each.

8.2.1 Each test finding shall be based on the average of at least five tests. Should there be obvious inconsistencies, additional tests shall be performed at the option of the Research Committee.

8.2.2 The test specimens of "stable" materials under Paragraph 5.1 are subject to tests set forth in Paragraphs 8.3 to 8.9, inclusive. Sufficient test specimens are to be prepared to permit a minimum of five tests in both a conditioned (control) only state and an accelerated aged state or as directed for each test.

8.3 Block Shear: ASTM D-905, "Strength Properties of Adhesive Bonds in Shear by Compression Loading." This test is required for *all* panel facings for which recognition is desired. Curing and conditioning in accordance with Paragraph 6 are necessary. Test specimens are to comply with Paragraph 5.4.1 or 5.5. *Only* hard Maple, Douglas fir or Coast Region test specimens must be tested as conditioned under Paragraph 6 and tested after accelerated aging under Paragraph 7.1. A third set of specimens must be tested after soaking under Paragraph 7.2 when a Class 2 adhesive is involved.

8.4 Shear Metal to Metal or Wood Specimens: Specimens for adhesives designed to bond metal to metal or metal to wood (hard Maple or Douglas fir to a metal), shall be fabricated under Paragraphs 5.6 and 5.7 and tested in accordance with ASTM D-1002, in both a conditioned (control) and accelerated aged state. An additional five specimens are to be tested in a conditioned state at a glue line test temperature of 182 degrees ± 2 degrees Fahrenheit in an uncontrolled humidity.

8.5 Bond: ASTM C-297, "Tension Tests of Flat Sandwich Construction in Flatwise Plane." This test is required for *all* facing materials for which recognition is desired and requires conditioning under Paragraph 6. Test specimens must be prepared in accordance with Paragraph 5.4.2 or 5.5. Hard Maple, Douglas fir, Coast Region or metal to metal test specimens are to have a minimum of five conditioned (control) only specimens tested and one set of five additional tests conducted on specimens which have been accelerated aged in accordance with Paragraph 7.1. One additional set is required for tests under Paragraph 7.2 where Class 2 adhesives are required. The test report is to indicate whether the adhesive or the laminating material failed and the percentage failure of each along with the information required by ASTM C-297.

8.5.1 Specimens for adhesives designed to bond metal to wood (hard maple or Douglas fir to a metal) or metal to metal must comply with Paragraph 5.7.

8.5.2 Bond tests with stable materials in Paragraph 5.1 or weather-resistive materials shall be conducted on both conditioned (control) only specimens and on accelerated aged specimens under Paragraph 7.

8.6 Creep: The creep test is to be performed on all Type II adhesives in compliance with ASTM D-2294, "Creep Properties of Adhesives in Shear by Tension Loading (Metal to Metal)." The desired shear stress must be predetermined so test specimens can be loaded to that stress plus 25 percent.

8.6.1 The test specimens are prepared under Paragraph 5.6. Tests are conducted to determine the allowable shear strength for Class 2 adhesives. Allowable creep is limited to an average of .002 inch per inch in the first hour for each test, with an average of .005 inch per inch during the entire duration of each test. The testing laboratory is to scribe the test markings on each specimen prior to applying the test load, with a reading taken immediately after loading and then at the prescribed intervals mentioned later.

8.6.2 The specimens are conditioned under Paragraph 6 prior to loading and testing. One set of five specimens is tested as conditioned (control) only for a period of 30 days in an uncontrolled temperature and humidity, taking creep readings every hour for the first eight hours, daily for the next seven days and then weekly for the remainder of the 30-day duration.

8.6.3 A second set of five specimens shall be tested as conditioned (control) only specimens in an uncontrolled humidity at an elevated temperature of 158 degrees ± 5 degrees Fahrenheit for one week. The temperature shall be 182 degrees ± 2 degrees Fahrenheit where bonded metal surfaces are involved. Creep readings are taken every hour for the first eight hours and then twice daily for the remainder of the test. The two test series may be conducted simultaneously.

8.6.4 Specimens for adhesives designed to bond metal to wood or metal to metal are prepared in accordance with Paragraph 5.6.2 or 5.7. The specimens are then tested under Paragraphs 8.6.2 and 8.6.3. Results are to be controlled by the same limitations set in Paragraph 8.6.1.

8.6.5 Specimens under Paragraph 5.9 shall be tested in an uncontrolled temperature and humidity condition under Paragraph 8.6 for seven days, with readings taken at intervals specified in Paragraph 8.6.3. All creep measurements shall be recorded for comparison with the related tests.

8.7 Oxidation: Adhesives such as elastomers, synthetic elastomers, rubber cements or others suspected of being affected by long-term aging shall be evaluated under ASTM D-572, "Standard Method of Test for Accelerated Aging of Vulcanized Rubber by the Oxygen-Pressure Method." The adhesives must first be evaluated for possible ingredients known to react violently with oxygen at the test pressures or temperatures. If they exist, the alternate ozone test described in Paragraph 8.7.2 shall be conducted.

8.7.1 Five block shear test specimens prepared in accordance with Paragraph 5.4.1 are conditioned under Paragraph 6 and then subjected to suspension in an oxygen atmosphere at 158 degrees ±5 degrees Fahrenheit and 300 ± 15 pounds per square inch pressure for a period of 500 hours. The temperature shall be 182 degrees ± 2 degrees Fahrenheit where bonded metal surfaces are involved. After exposure, the specimens are again conditioned and then tested immediately in accordance with ASTM D-905, "Strength Properties of Adhesive Bond in Shear by Compression Loading."

Specimens utilizing adhesives designed to bond metal to metal or metal to wood are to be prepared in accordance with Paragraph 5.6.2 or 5.7. They are then subjected to the oxidation test in Paragraph 8.7, conditioned as indicated therein and tested in accordance with ASTM D-1002 for shear.

8.7.2 As an alternate to the oxidation test, the test procedure under ASTM D-1149, "Accelerated Ozone Cracking of Vulcanized Rubber," may be used. Paragraphs 3, 4, 5, 6 and 7 provide the equipment specifications for conducting the tests. The ozone concentration shall be 50 parts per 100,000,000 by volume, measured before and adjusted after the introduction of the test specimens into the chamber, then twice daily once the proper concentration has been reached. The standard chamber temperature is to be 122 ± 2 degrees Fahrenheit for the duration of each test.

8.7.2.1 Five block shear test specimens, prepared and conditioned in accordance with Paragraphs 5.4.1 and 6 are subjected to suspension in the ozone test chamber for a period of 72 hours. After exposure, the specimens are again conditioned and tested immediately in accordance with ASTM D-905, "Strength Properties of Adhesive Bonds in Shear by Compression Loading."

8.7.2.2 Adhesives designed to bond metal to metal or metal to wood are prepared and tested as for the oxidation test, except the ozone test in Paragraph 8.7.2 is used in place of the oxidation test.

8.8 Mold: Mold resistance shall be determined in accordance with ASTM D-1877, "Permanence of Adhesive Bonded Joints in Plywood Under Mold Conditions." Ten specimens of hard Maple or Douglas fir, Coast Region material are prepared in accordance with Paragraphs 5.4.1 and 5.4.3, conditioned under Paragraph 6 and then inoculated and exposed as noted in Paragraph 6 of ASTM D-1877. Exposure shall be for eight weeks after which the specimens are tested under ASTM D-905 and ASTM C-297, respectively. The percentage efficiency of the inoculated specimens as compared to the conditioned (control) only specimens must exceed 90 percent unless the adhesive is classified as Type I, Class 1.

8.9 Chemical Reagents: Five adhesive specimens each are prepared in accordance with Paragraphs 5.4.1 and 5.4.2. All samples are then conditioned under Paragraph 6 and exposed to chemical reagents for which recognition of resistance is desired. The tests are conducted in accordance with ASTM D-896, "Resistance of Adhesive Bonds to Chemical Reagents." The adhesive shall demonstrate no loss of strength when the specimens are tested by ASTM D-905 and ASTM C-297, respectively. The test may be waived when the adhesive is limited to use in Groups "H" and "I" Occupancies except where fire-retardant or preservative treatment is involved.

8.10 Compatibility: The adhesive or sandwich panel proponent shall indicate the core materials he desires recognition as compatible with the adhesive. For spray applications, three representative samples of each core material shall have the following adhesive coatings applied to a smooth, even surface. In three immediate consecutive spray applications, each at a rate to provide one-half the final recommended thickness, one coat shall be applied to three specimens, a second coat to two specimens and a third coat to one specimen.

When a spray application is not recommended, the three samples shall have one-half, full and one and one-half the recommended thickness of adhesive applied in accordance with the adhesive manufacturer's standard instructions, except for the thickness.

Additionally, ten 2-inch square specimens of each core material shall be coated and bonded in pairs with the recommended adhesive thickness to form a specimen for testing under ASTM C-297. Bond strength in accordance with ASTM C-297 is then determined after the three week period noted in Paragraph 8.10.2.

8.10.1 All samples shall be maintained at the recommended temperature and humidity during panel fabrication and observations made concerning the surfaces and edges during the drying or curing period.

8.10.2 All samples shall be retained in areas of uncontrolled moisture and temperature after drying and observations made at the end of the first, second and third week. Any evidence of deterioration, softening, hardening or cracking of the samples noted during the application, curing and observation periods shall be reported. The core material should be of different densities when polyurethane, polystyrene foams or similar materials are used to assure compatibility over a range of core applications.

8.11 Core-Facing Bond: Testing specified in ASTM C-393, "Flexure Test of Flat Sandwich Constructions," shall be conducted when there is insufficient evidence that core shear failure will consistently occur before failure at the bond line between the core and facing.

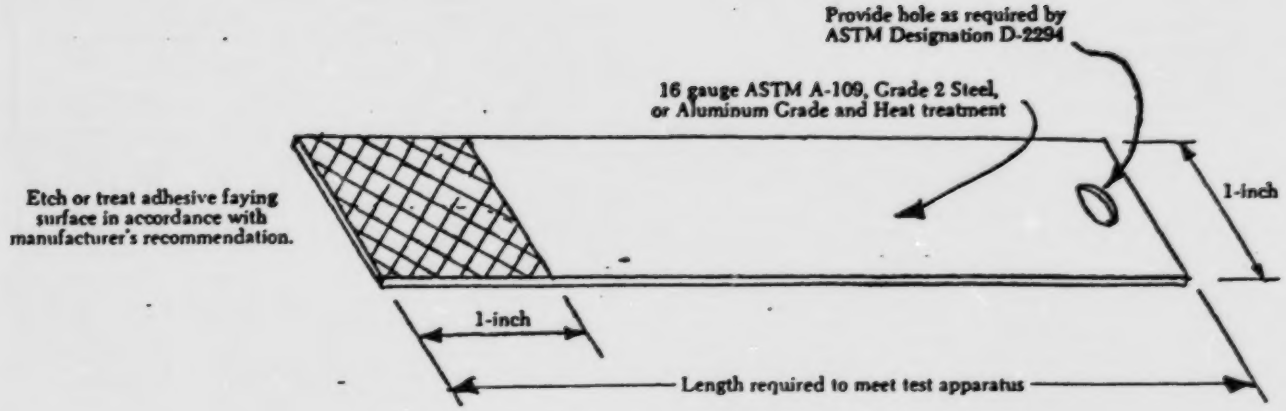
9. FACTORS OF SAFETY: A factor of safety of generally five, based on ultimate loads derived from tests, shall be used. The lowest ultimate load values for each test, based on either the conditioned (control) or the accelerated aged specimens shall be used. Modification of this requirement will be considered if tests yield consistent results, conditions of use are clearly delineated and other pertinent conditions raised by the Research Committee are resolved.

Increases to allowable stresses based on duration of loading shall be limited to specific conditions set by the Research Committee.

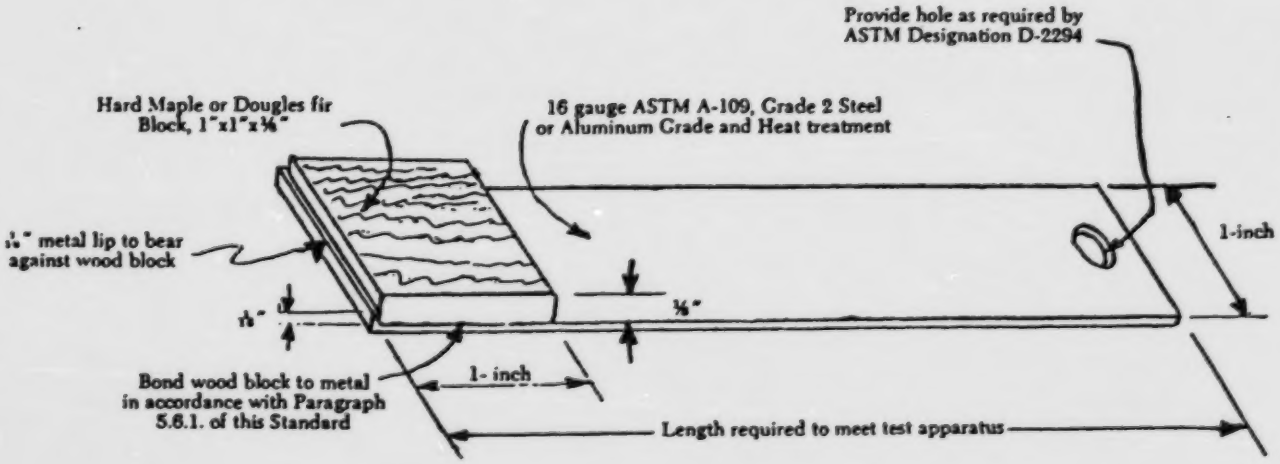
FIGURE NO. 1 — TEST TABULATION

CATEGORY	RESEARCH REPORT[4]		SPECIMEN[1,2]	CONDITIONING[1,2]	AGING[1]	TEST PROCEDURE[2]
	Adhesive	Panel				
SHEAR	X	–	5.4.1 Maple or Douglas fir	6	7	8.3
	X[5]	–	5.1.3 & 5.7 Metal or Fiberglass	6	7	8.4
	–	X	5.5 Other Facing Materials	6	None	8.3
BOND	X	–	5.4.2 Maple or Douglas fir	6	7	–
	X[5]	–	5.1.3 & 5.7 Metal	6	7	8.5
	–	X	5.5 Other Facing Materials	6	None	–
CREEP (Not Required For Type I Adhesives)	X	–	5.6.1 & 5.9 Maple or Douglas fir	6	None	8.6
	X[5]	–	5.1.3, 5.7 & 5.9 Metal	6	None	8.6
OXIDATION[6]	X	–	5.4.1 Maple or Douglas fir	6	8.7	8.7.1 or 8.7.2.1
	X	–	5.1.3, 5.6.2 & 5.7 Metal	6	8.7	8.7.1 or 8.7.2.2
MOLD	X	–	5.4.1 & 5.4.2 Maple, Douglas fir or Metal	6	None	8.8
CHEMICAL REAGENTS[3]	–	X	5.4.1 & 5.4.2 Maple or Douglas fir	6	None	8.9
CORE COMPATIBILITY	–	X	Core	8.11.1 & 2	None	8.10
CORE-FACING BOND	–	X	Core-Facing	6	None	8.11

[1]Reference number refers to Paragraph in Standard.
[2]Paragraph 5.2 applicable generally and 5.3 in shear and bond tests.
[3]Includes fire-retardant and preservative treatments.
[4]Tests for panel reports assume that an adhesive already approved will be used. The adhesive manufacturer may also include panel materials in the report as an optine. See Paragraph 1.2.
[5]Shear, bond and creep tests on steel and fiberglass samples are optional in an adhesive report if the manufacturer does not wish recognition for these materials.
[6]Qualifying tests with wood or steel samples are acceptable for all core and facing materials.
[7]See test procedures for variations.


Provide hole as required by
ASTM Designation D-2294
16 gauge ASTM A-109, Grade 2 Steel,
or Aluminum Grade and Heat treatment
Etch or treat adhesive faying
surface in accordance with
manufacturer's recommendation.
1-inch
1-inch
Length required to meet test apparatus

One required for each specimen in Paragraph 5.6.2.



Two required for each specimen in Paragraph 5.6.1.
One required for each specimen in Paragraph 5.6.2.

FIGURE NO. 2

APPENDIX C

WARNOCK HERSEY STRUCTURAL TEST REPORT

ON NASCOR II R20 WALL PANELS

Warnock Hersey Professional Services Ltd.
211 Schoolhouse Street, Coquitlam, B.C. V3K 4X9 Tel: (604) 520-3321 Envoy WPM 8076

REPORT OF:

TRANSVERSE LOAD TEST

AXIAL LOAD TEST

RACKING LOAD TEST

ON

CANO STRUCTURES INC.
NASCOR R20 WALL SYSTEM

REPORT NO. 1/86

DATE: OCTOBER 8, 1986

BY: F. Mawani

F. MAWANI, P. Eng.,
Manager,
Field Inspections

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INTRODUCTION:

As requested, we have carried out load tests on Cano Structures Nascor R20 Wall System described below. The tests were conducted in accordance with ASTM Standard E72-80. "Standard Methods of Conducting Strength Tests of Panels for Building Construction." The purpose of these tests was to determine the structural properties of segments of a wall panel developed by Cano Structures Inc.

DESCRIPTION OF NASCOR R-20 WALL SYSTEM

The Nascor R20 Wall System test panels consisted of 140 mm (5 1/2") thick wall panels measuring 2440 mm (8'0") high by 1220 mm (4'0") wide with NASCOR columns spaced at 600 mm (24") on center with 140 mm (5 1/2") thick expanded polystyrene insulation infill panels between the columns. One 38 mm x 140 mm (2" x 6") bottom plate and a double 38 mm x 140 mm (2" x 6") top plates screwed to the studs. All wood is graded S.P.F. #1 and #2. Type 1 expanded polystyrene insulation is used for infill panels.

The NASCOR R20 column consists of a 64 mm (2 1/2") thick by 89 mm (3 1/2") wide expanded polystyrene core adhered to the 89 mm (3 1/2") face of each of the two 38 mm x 89 mm (2 x 4) wood membranes (i.e. 2 wood members and a polystyrene core per column). The NASCOR R20 columns are placed in the wall assembly in such a manner that the long dimension of the 38 mm x 89 mm (2 x 4) wood members, which is the 89 mm (3 1/2") side, is parallel to the plane of the wall rather than the conventional method of placing studs with wide face perpendicular to the plane of the wall. A NASCOR column therefore measures 140 mm (5 1/2") thick (to match the wall thickness) by 89 mm (3 1/2") wide (the width of the wood members). The expanded polystyrene infill panels are interlocked with the column cores to hold the infill panels in place.

TEST PROCEDURES

1. TRANSVERSE LOAD TEST

Tests were carried out in accordance with ASTM E72-80. Tests were performed on three like specimen of the wall system without any sheathing on either side. Two additional tests were carried out on the wall system with 12.5 mm (1/2") gyproc sheathing on the compression side (i.e. top side) and one additional test was performed with 12.5 mm (1/2") gyproc sheathing on the tension side.

4' x 8' test panels were placed horizontally in the test frame on a span of 2286 mm (90"). Loads were applied at the quarter points, using a hydraulic ram and pump system. At each increment of the load, the deflection of the panel at mid span was measured, using dial indicators reading to 0.001". An average of the two readings, (one on either side of the panel) was calculated. Load deflection data is tabulated and plotted. Stiffness of the 4' wide panel up to a deflection of span/180 was calculated (The initial stiffer portion of the curve) using linear regression and standard engineering formulas for loading conditions.

Two additional Transverse Load tests were carried out on 3454 mm (136") spans to determine any change in the stiffness value due to increased span.

CALCULATIONS FOR TRANSVERSE LOAD TEST

Stiffness EI of 4' wide section = $\frac{11P\ L^3}{2x\Delta x\ 384}$

Where P = Total Load (lbs)
L = Span ins.
Δ = Deflection ins.

FOR TEST PANELS WITHOUT ANY SHEATHING

Test 1 EI = 19.114×10^6 psi. Ultimate Load = 3621 lbs.

Test 2 EI = 25.022×10^6 psi. Ultimate Load = 4146 lbs.

Test 3 EI = 23.982×10^6 psi. Ultimate Load = 4197 lbs.

Test 4 EI = 22.193×10^6 psi. Not Recorded. Panel bottomed out.

Test 5 EI = 23.360×10^6 psi. Not Recorded. Panel bottomed out.

Average EI = 22.734×10^6 psi.

$\therefore$ Average EI/Stud Column = $\frac{22.734 \times 10^6}{3}$

$= 7.578 \times 10^6$ psi

$\therefore$ From the above results, limiting loads for various spans have been calculated as below:

For wall panels with studs at 24" o.c.

Span (L) ft. Allowable Load (psf) for Deflection of

	L/180	L/240
8'	21.9	16.4
9'	15.4	11.6
10'	11.3	8.4

Note: Wind blowing at 75 mph exerts a load of 14 psf on the wall.

2. AXIAL LOAD TEST

Tests were carried out in accordance with ASTM E72-80. Tests were performed on three like specimen 4' wide x 8' high. Tests were performed without any sheathing on the panels. The specimen was placed in the load frame vertically and the load was applied with a hydraulic ram and pump system.

At each increment of the load, the deflection at the center of the wall was recorded and set after the load was removed at each increment. The results were tabulated and plotted.

TEST RESULTS:

	PANEL NUMBER			
	1	2	3	Average
Ultimate Load (lbs)	25,400	24,996	23,316	24,571
Ultimate Load (lbs/stud col.)	8,476	8,332	7,772	8,190
Allowable Ultimate Load (lbs/ft) with safety factor of 3.	1,411	1,388	1,295	1,365
Lateral Deflection of the Wall at centre at maximum allowable axial load.	0	0	0.030	0.010

3. RACKING LOAD TEST

Racking load test was performed on three like specimens. Tests were performed on 8' x 8' wall panels in accordance with ASTM Standard E72-80. The panels had a 1/2" gyproc sheathing on one side.

The panels were placed vertical in the test frame and the load was applied using a hydraulic ram and pump system. Deflections and sets were measured using a dial indicator reading to 0.001".

Test results were tabulated and plotted on a graph.

TEST RESULTS:

	PANEL NUMBER			
	1	2	3	Average
Ultimate Load (lbs)	1,668	1,403	1,403	1,491
Ultimate Load (lbs/lin.ft.)	209	175	175	186
Allowable Ultimate Load (lbs/lin.ft.) with safety factor 3	70	58	58	62
Deflection (ins) at mid span at maximum allowable load. (Deflection for 8' wide wall is recorded)	0.20	0.20	0.20	0.20

DISCUSSION OF TEST RESULTS

1. TRANSVERSE LOAD TEST

From the test results it can be seen that for a fixed span the stiffness (EI) of the panel decreases with the increasing load.

Since the design of such walls are limited by the allowable deflections, it was considered reasonable to use the load deflection data from the laboratory tests slightly exceeding span/180 deflections. Span/180 deflections are considered to be the maximum allowed for design purpose by any approving authorities. Some authorities only allow span/240 deflections for walls.

Using test data up to span/180 deflections seem more realistic since designs are never going to exceed these.

From the test results obtained it can be seen that for the Nascor R20 column the EI value obtained is 7.578×10^6 psi.

For a common 2 x 4 S.P.F. grade stud, the modulus of elasticity is in the range of 1.2 to 1.3 million psi. Therefore EI value of a common 2 x 4 S.P.F. grade stud on edge would be $5.36 \times 1.3 \times 10^6 = 6.97 \times 10^6$ psi. So it can be seen that the Nascor R20 column is slightly stiffer than a common 2 x 4 S.P.F. grade stud, and we can safely recommend that a Nascor R20 column can be used in a building construction instead of a 2 x 4 S.P.F. grade stud.

2. AXIAL LOAD TEST

Axial load tests show that the stud can with a safety factor of 3 support an axial load of 2730 lbs. Actual maximum allowable load per column would only be 2570 lbs. since any load exceeding this will exceed the allowable value for S.P.F. grade lumber in compression perpendicular to the grain for the top plates. For a common 2 x 4 stud the maximum allowable axial load value will only be 1286 lbs. with S.P.F. grade top plates. So once again Nascor R20 column can be used instead of 2 x 4 S.P.F. grade stud.

DISCUSSION OF TEST RESULTS: Cont'd

3. RACKING LOAD

From the test results it was established that the wall with 1/2" gyproc sheathing on one side can take a racking shear load of 62 lbs. per linear foot of the wall.

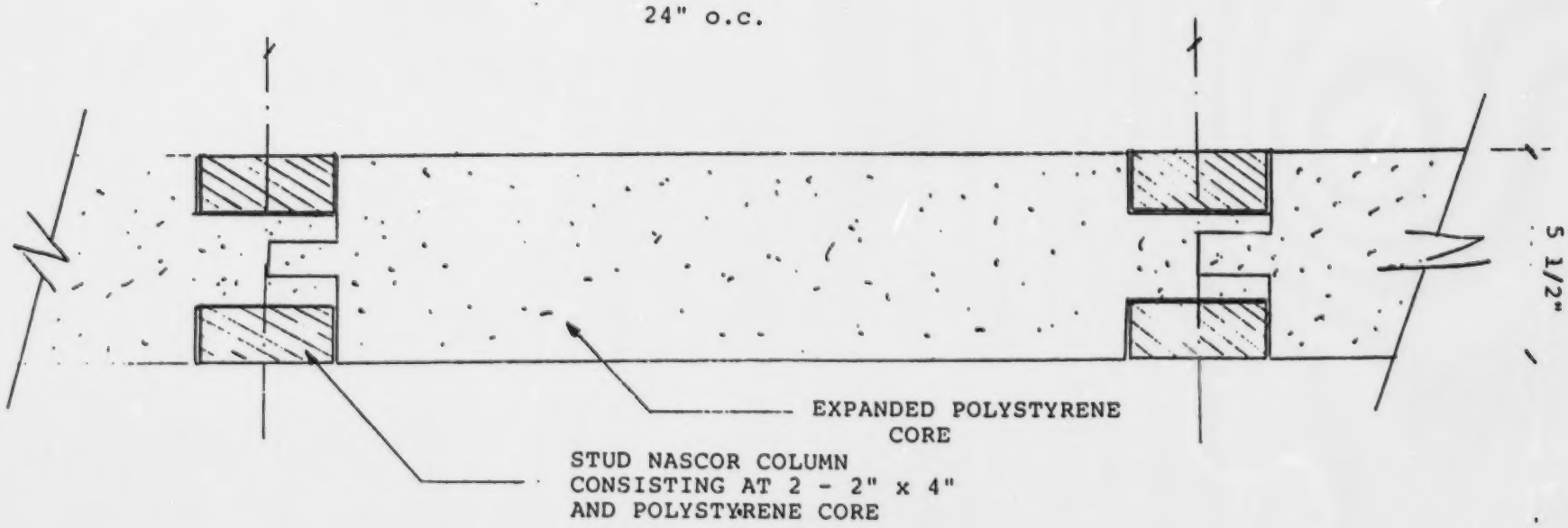
CONCLUSION:

After carrying out a number of Transverse Load tests. Axial Load tests and Racking Load tests, we can conclude that the Nascor R20 wall system is equivalent or slightly better than a standard 2 x 4 S.P.F. grade stud wall with the studs spaced at the same distance as Nascor R20 column. This applies to deflection conditions of up to span/180 only.

The expanded polystrene infill panels between the columns provide sufficient lateral bracing as can be seen from the test results that all axial load tests failed in a plane perpendicular to the wall and hence additional lateral bracing is not required.

The Nascor R20 wall system can safely be used where a standard 2 x 4 S.P.F. grade stud wall are used.

A P P E N D I X



TYPICAL WALL CROSS SECTION

NASCOR R20 WALL - TRANSVERSE LOAD DATA

NO GYPROC

SPAN = 90"

LOAD 1 LBS	DEFL 1 INS.	LOAD 2 LBS.	DEFL 2 INS.	LOAD 3 LBS.	DEFL INS.
0	0.000 *	0	0.000 *	0	0.000 *
357	0.170 *	306	0.104 *	306	0.101 *
677	0.343 *	738	0.264 *	666	0.253 *
965	0.516 *	1098	0.433 *	995	0.407 *
1263	0.683 *	1428	0.593 *	1294	0.557 *
1551	0.858	1705	0.751	1520	0.721
1737	1.024	1963	0.923	1685	0.876
1994	1.190	2159	1.089	1881	1.021
2169	1.353	2385	1.256	2087	1.190
2365	1.509	2591	1.421	2282	1.353
2509	1.652	2766	1.582	2406	1.460
2632	1.784	2972	1.744	2591	1.622
2674	1.908	3085	1.850	2776	1.782
				2930	1.941
Ultimate	3621 lbs.	4146 lbs.		4197 lbs.	
Slope	1830.6	2396.4		2296.8	
Corr.	.999	.997		.997	

EI Panel 19.114 x 10^6 psi 25.022 x 10^6 psi 23.982 x 10^6

Average EI/Stud 7.569 x 10^6 psi (3 studs per panel)

* Data used for calculation of EI.

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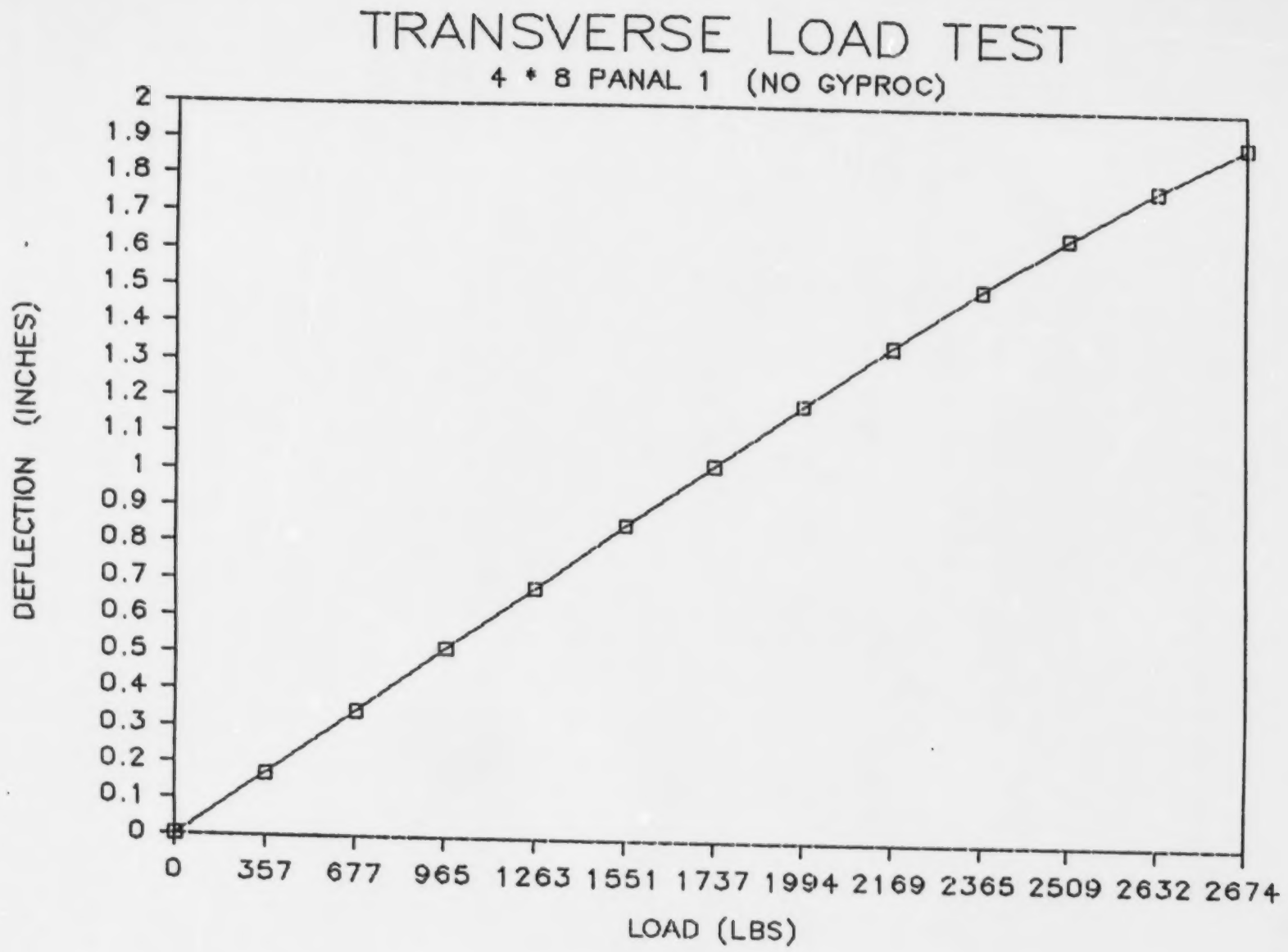
NASCOR R20 WALL TRANSVERSE LOAD DATA

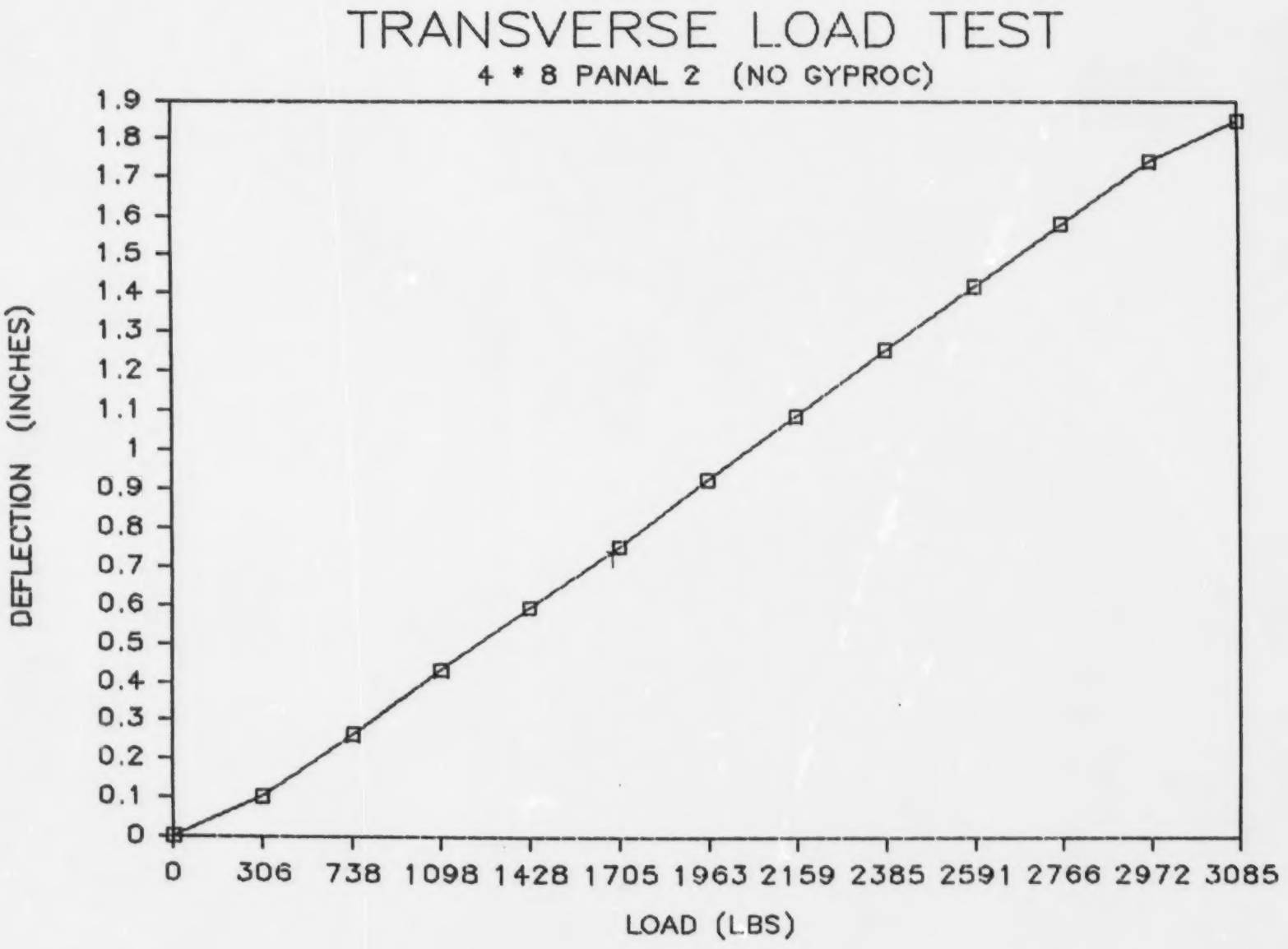
NO GYPROC

SPAN = 136 inches

LOAD 4	DEFL. 4	LOAD 5	DEFL. 5
0	0 *	0	0
200	.285	100	.105 *
400	.614	200	.264 *
500	.814	300	.388 *
600	.995	400	.552 *
700	1.240	500	.769 *
800	1.486	600	.997
900	1.799	700	1.178
1000	-	800	1.393
		900	1.682
Slope 615.0		648.4	
Corr. .998		.993	
EI Panel 22.193 x 10^6 psi		23.360 x 10^6 psi	

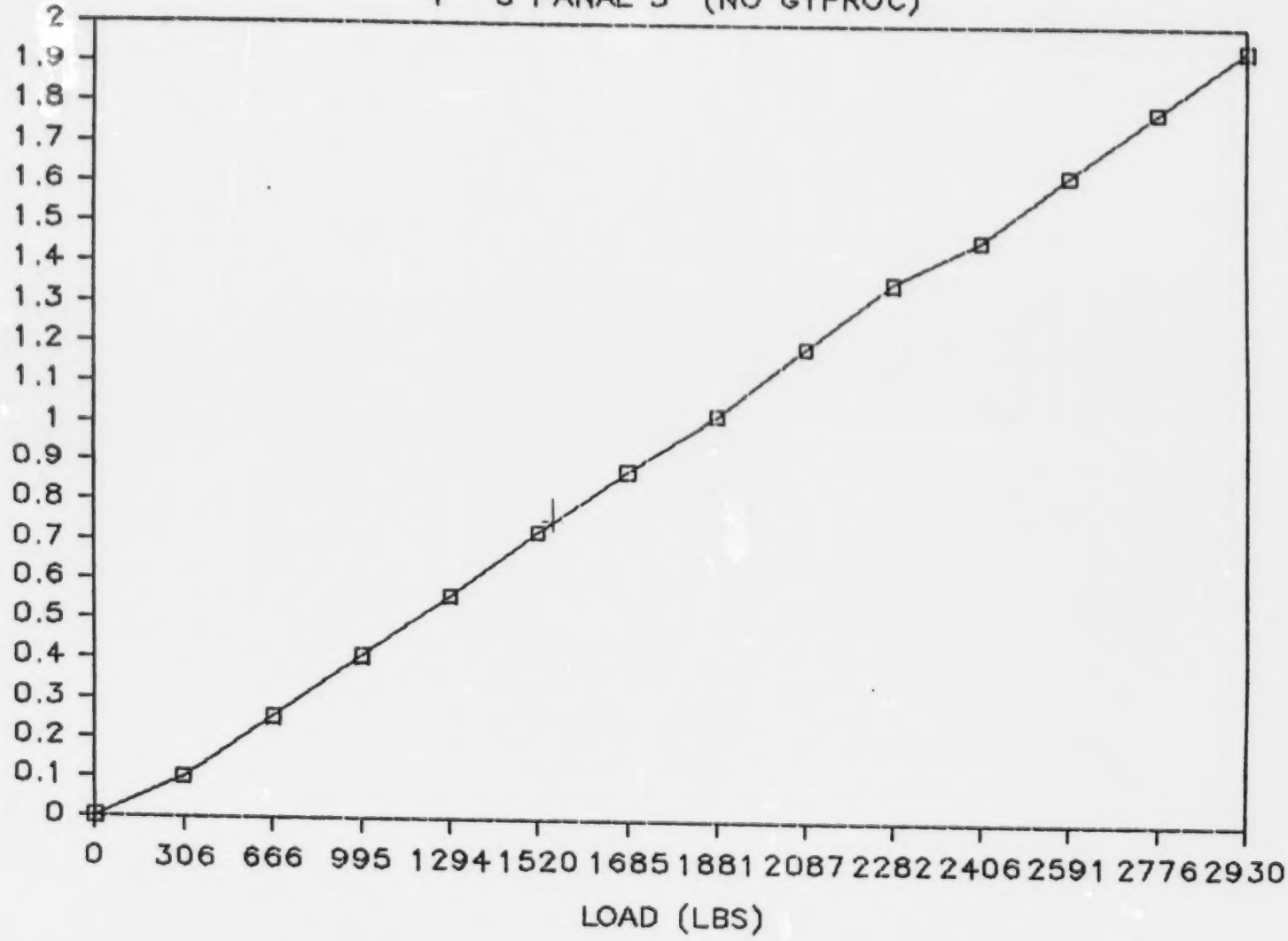
Average EI/Stud 7.592 x 10^6 psi (3 stud per panel)


TRANSVERSE LOAD TEST
4 * 8 PANAL 1 (NO GYPROC)
DEFLECTION (INCHES)
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0 357 677 965 1263 1551 1737 1994 2169 2365 2509 2632 2674
LOAD (LBS)

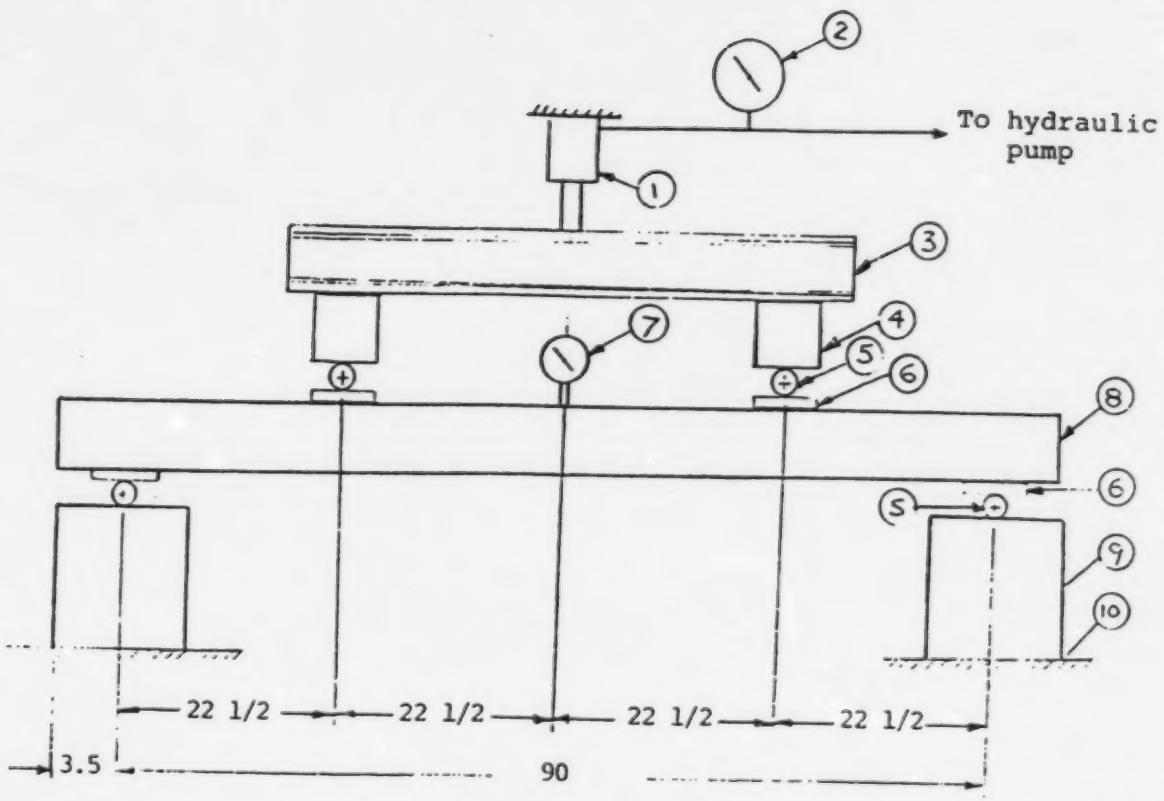

TRANSVERSE LOAD TEST
4 * 8 PANAL 2 (NO GYPROC)
DEFLECTION (INCHES)
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0 306 738 1098 1428 1705 1963 2159 2385 2591 2766 2972 3085
LOAD (LBS)

TRANSVERSE LOAD TEST

4 * 8 PANAL 3 (NO GYPROC)



TRANSVERSE LOAD TEST DIAGRAM

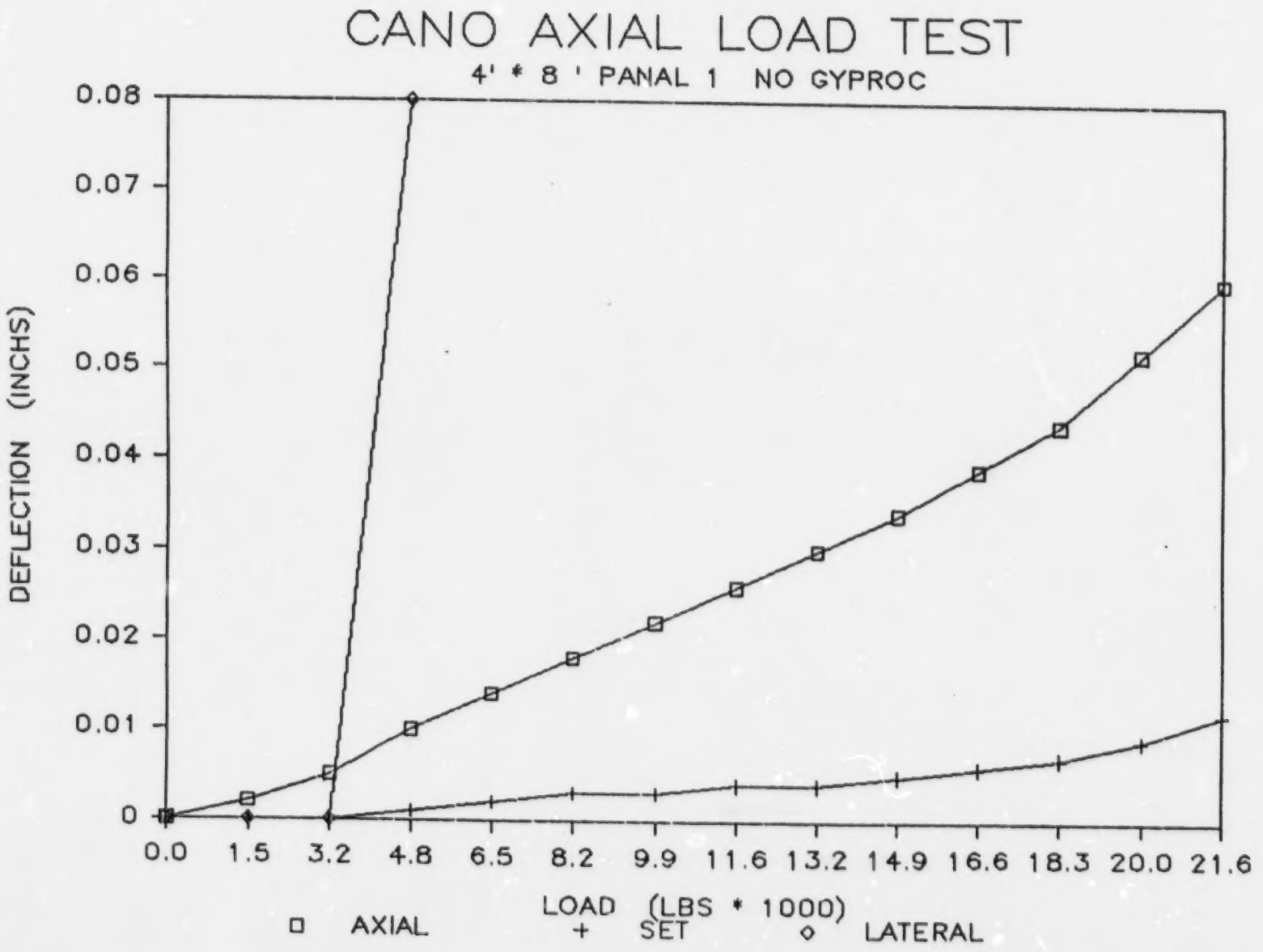


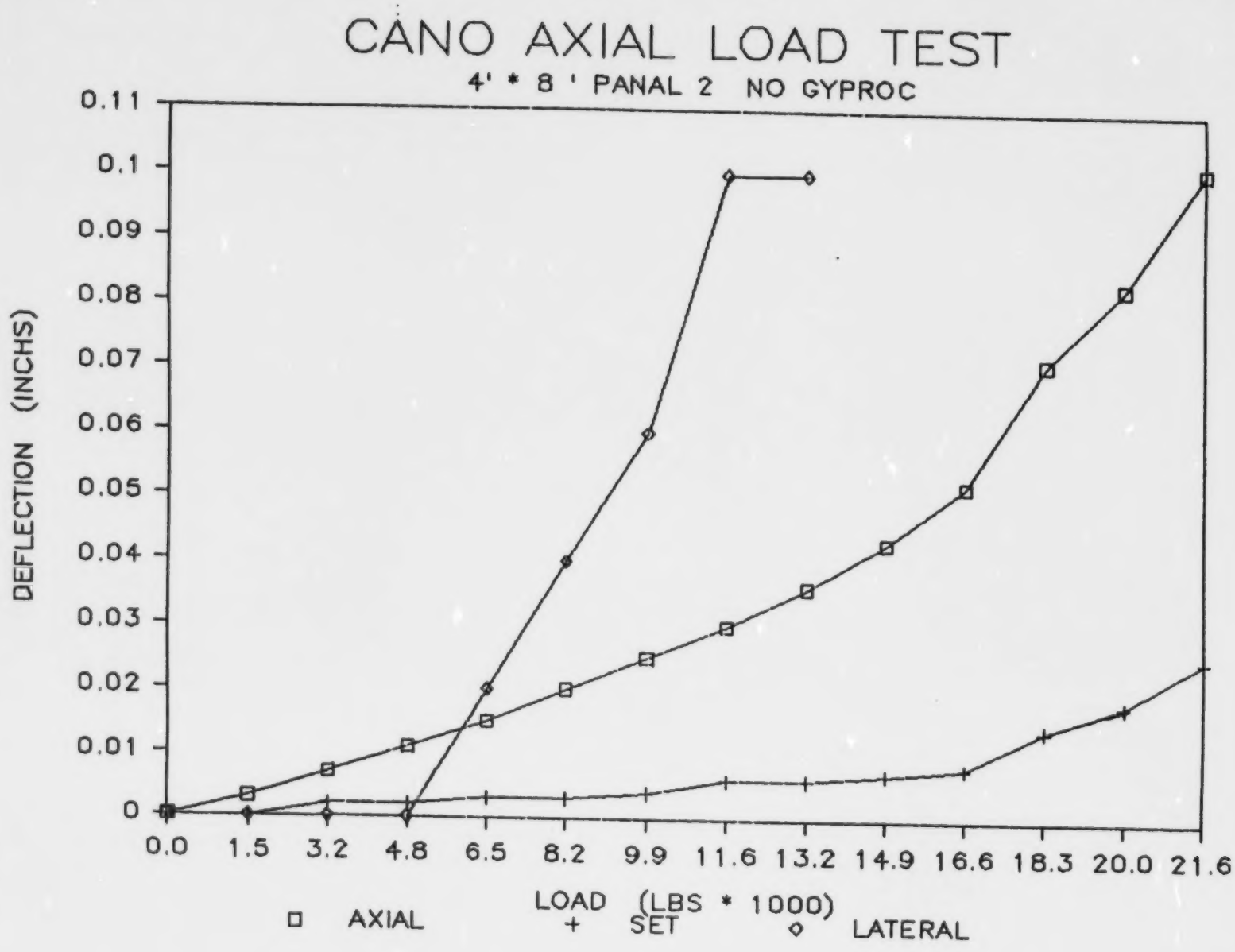
1. Hydraulic Ram
2. Calibrated Pressure Gauge
3. 4" x 48" I Beam
4. 4 x 4 x 48" Beam
5. 1"x 48" Steel Roller
6. 1/4" x 3" x 48" Steel Plate
7. Dial Micrometer (1 each side, attached to reaction frame)
8. Test Specimen
9. Cement Block
10. Reaction Frame

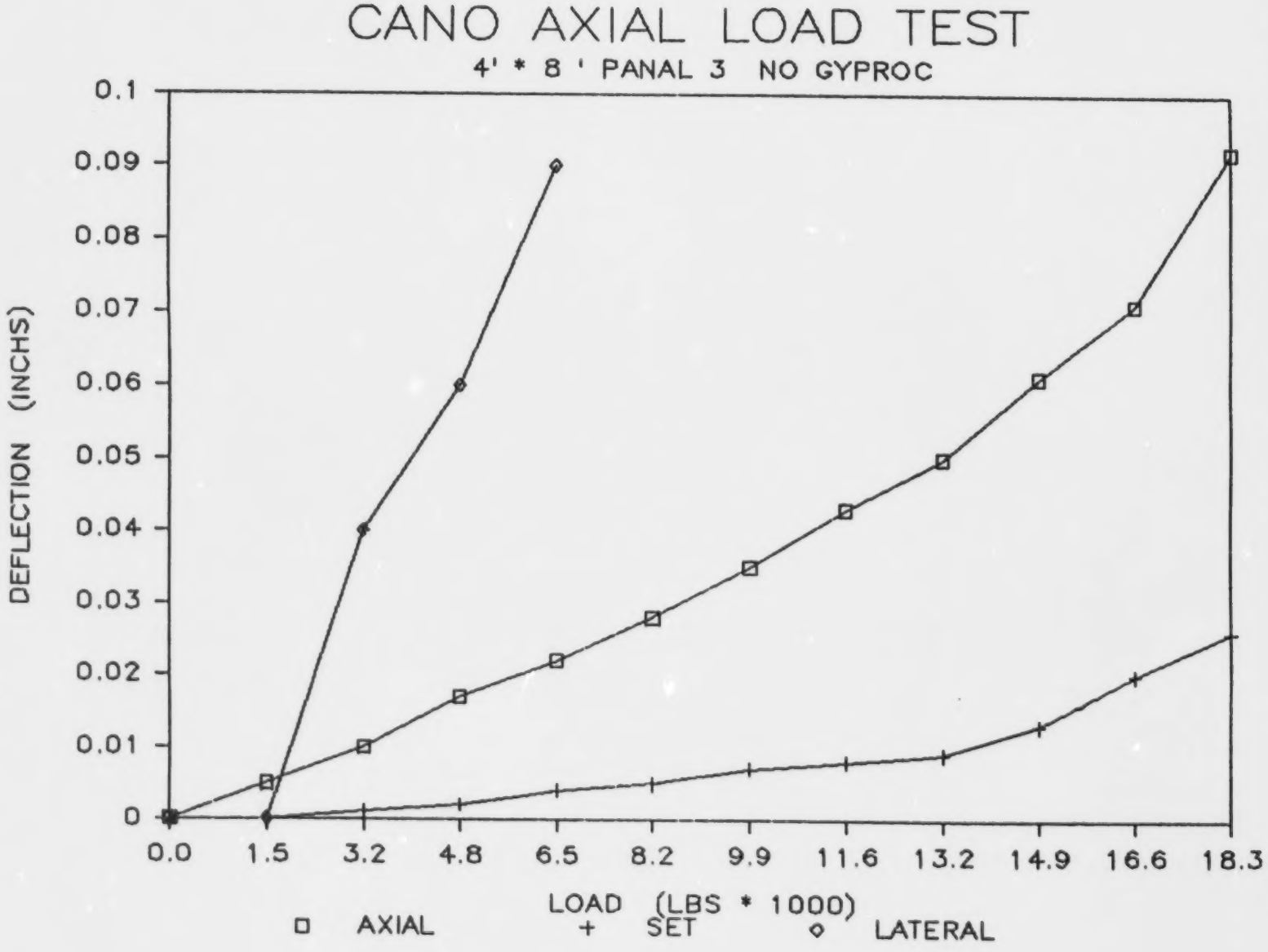
Note: All dimensions are measured in inches unless otherwise noted.

NASCOR R20 WALL SYSTEM
AXIAL LOAD TEST DATA

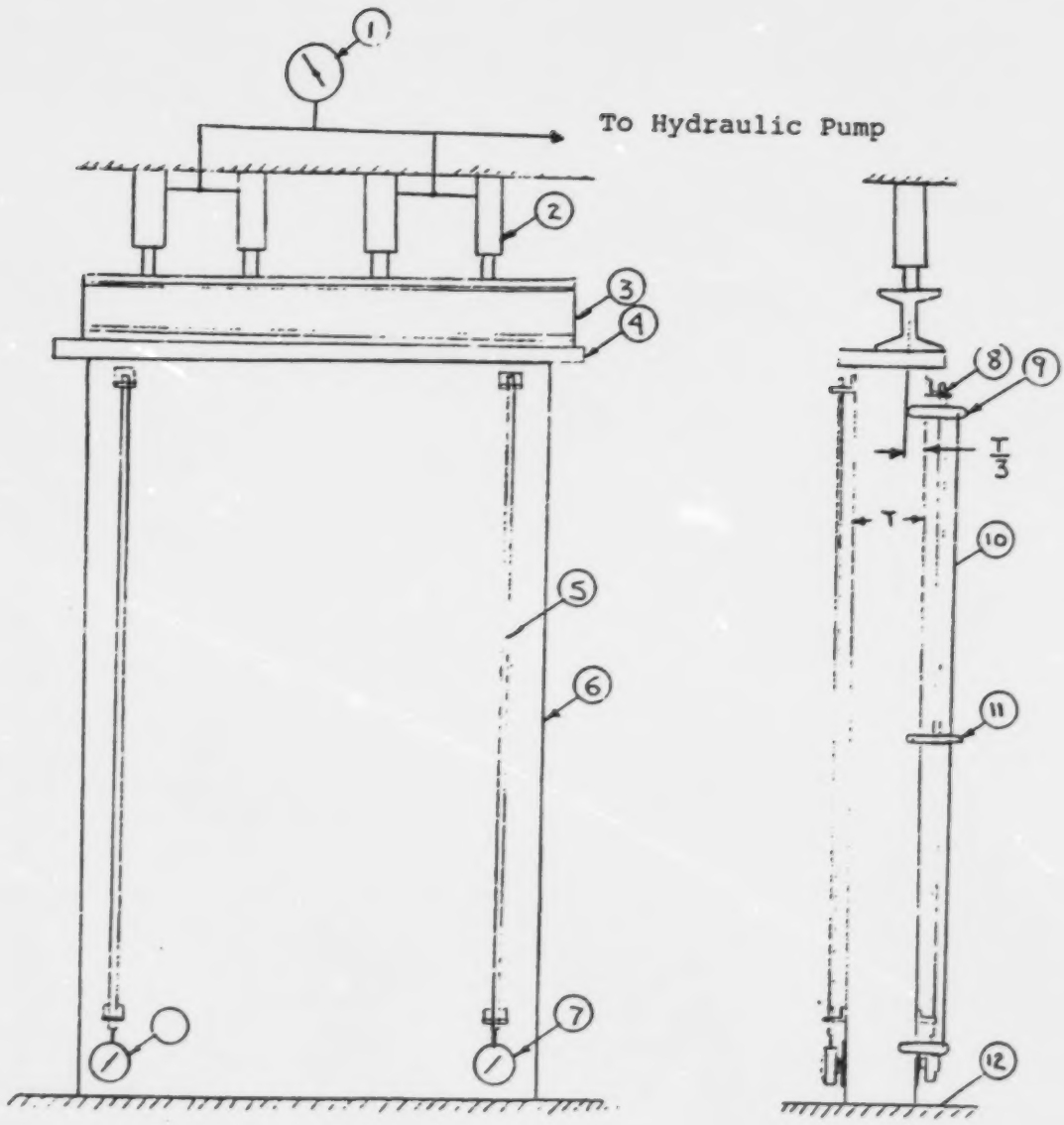
PANEL # 1				PANEL 2			PANEL 3		
LOAD LBS *1000	DEFL INCH	SET INCH	LATERAL INCH	DEFL INCH	SET INCH	LATERAL INCH	DEFL INCH	SET INCH	LATERAL INCH
0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1.5	0.002	0.000	0.000	0.003	0.000	0.000	0.005	0.000	0.000
3.2	0.005	0.000	0.000	0.007	0.002	0.000	0.010	0.001	0.040
4.8	0.010	0.001	0.080	0.011	0.002	0.000	0.017	0.002	0.060
6.5	0.014	0.002	0.100	0.015	0.003	0.020	0.022	0.004	0.090
8.2	0.018	0.003	0.160	0.020	0.003	0.040	0.028	0.005	0.110
9.9	0.022	0.003	0.160	0.025	0.004	0.060	0.035	0.007	0.140
11.6	0.026	0.004	0.160	0.030	0.006	0.100	0.043	0.008	0.160
13.2	0.030	0.004	0.200	0.036	0.006	0.100	0.050	0.009	0.200
14.9	0.034	0.005	0.240	0.043	0.007	0.160	0.061	0.013	0.300
16.6	0.039	0.006	0.310	0.052	0.008	0.170	0.071	0.020	0.370
18.3	0.044	0.007	0.400	0.071	0.014	0.180	0.092	0.026	0.450
20.0	0.052	0.009	0.550	0.083	0.018	0.260			
21.6	0.060	0.012	0.700	0.101	0.025	0.310			
ULTIMATE 25400				ULTIMATE 24996			ULTIMATE 23316		


CANO AXIAL LOAD TEST
4' * 8 ' PANAL 1 NO GYPROC
DEFLECTION (INCHS)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.0 1.5 3.2 4.8 6.5 8.2 9.9 11.6 13.2 14.9 16.6 18.3 20.0 21.6
LOAD (LBS * 1000)
AXIAL
SET
LATERAL


CANO AXIAL LOAD TEST
4' * 8 ' PANAL 2 NO GYPROC
DEFLECTION (INCHS)
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.0 1.5 3.2 4.8 6.5 8.2 9.9 11.6 13.2 14.9 16.6 18.3 20.0 21.6
LOAD (LBS * 1000)
AXIAL
SET
LATERAL


CANO AXIAL LOAD TEST
4' * 8 ' PANAL 3 NO GYPROC
DEFLECTION (INCHS)
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.0
1.5
3.2
4.8
6.5
8.2
9.9
11.6
13.2
14.9
16.6
18.3
LOAD (LBS * 1000)
AXIAL
SET
LATERAL

AXIAL LOAD TEST DIAGRAM



1. Calibrated Pressure Gauge
2. Hydraulic Rams
3. 4" x 48" I Beam
4. 1/4" x 6" x 48" steel plate
5. Steel Rod
6. Test Specimen 48 x 96
7. Dial Micrometers (4)
8. L. Bracket
9. Wire Clamp
10. Wire
11. Deflectometer
12. Reaction Frame

NASCOR R20 WALL SYSTEM
RACKING SHEAR TEST DATA

NOTE: ALL DEFLECTIONS IN INCHES

PANAL 1

LOAD LBS	DEFL 1 LD SIDE	DEFL 2 BOTTOM	DEFL 3 TOP	SET 1	SET 2	SET 3
0	0.000	0.000	0.000	0.000	0.000	0.000
227	0.011	0.000	0.068			
467	0.024	0.003	0.186			
790	0.049	0.006	0.468	0.018	0.003	0.212
948	0.053	0.008	0.548			
1188	0.069	0.010	0.834			
1570	0.076	0.016	1.422	0.060	0.008	0.700
1668	0.093	0.019	1.814			

PANAL 2

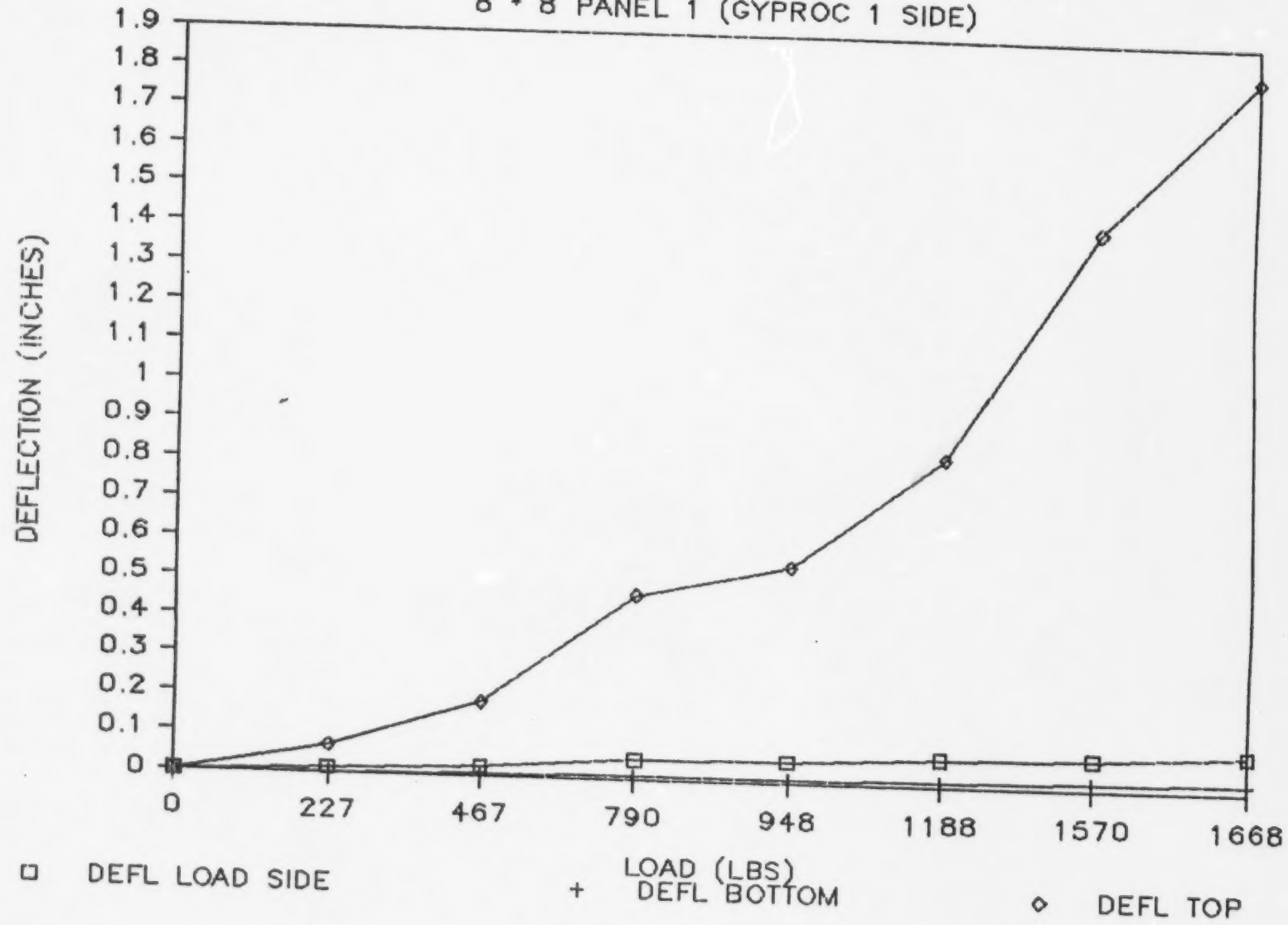
LOAD LBS	DEFL 1 LD SIDE	DEFL 2 BOTTOM	DEFL 3 TOP	SET 1	SET 2	SET 3
0	0.000	0.000	0.000	0.000	0.000	0.000
154	0.012	0.001	0.043			
279	0.014	0.003	0.105			
404	0.019	0.003	0.178			
529	0.027	0.004	0.260			
654	0.045	0.005	0.398			
790	0.049	0.005	0.565	0.023	0.002	0.270
903	0.135	0.006	0.775			
1028	0.140	0.008	0.968			
1153	0.155	0.008	1.142			
1403	0.240	0.008	1.574			

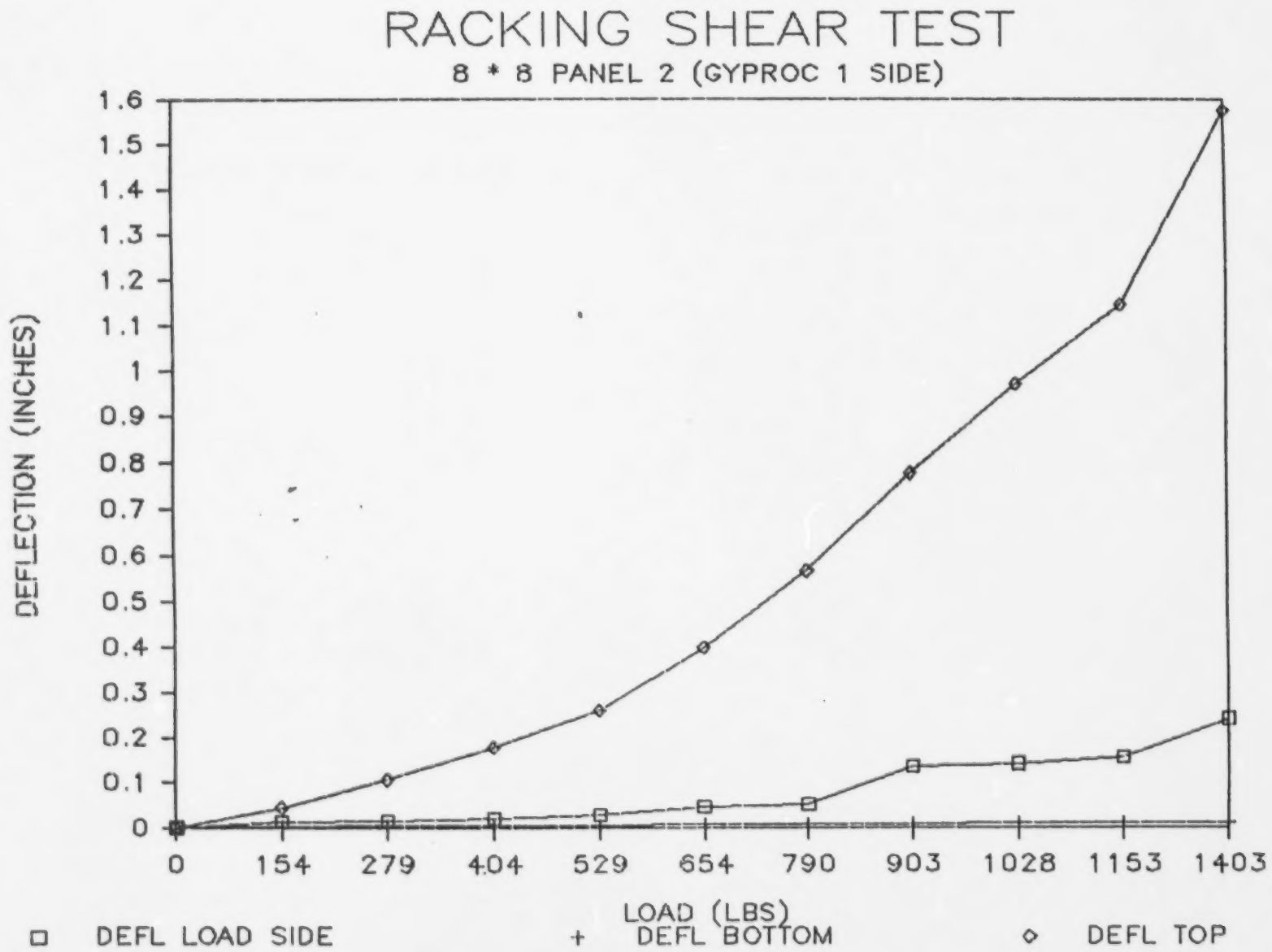
PANAL 3

LOAD LBS	DEFL 1 LD SIDE	DEFL 2 BOTTOM	DEFL 3 TOP	SET 1	SET 2	SET 3
0	0.000	0.000	0.000	0.000	0.000	0.000
154	0.001	0.001	0.059			
279	0.014	0.003	0.180			
404	0.019	0.005	0.261			
529	0.027	0.060	0.378			
654	0.045	0.087	0.567			
790	0.049	0.115	0.753	0.013	0.082	0.305
903	0.135	0.120	0.948			
1028	0.140	0.125	1.089			
1153	0.155	0.127	1.273			
1403	0.240	0.132	1.725			

RACKING SHEAR TEST

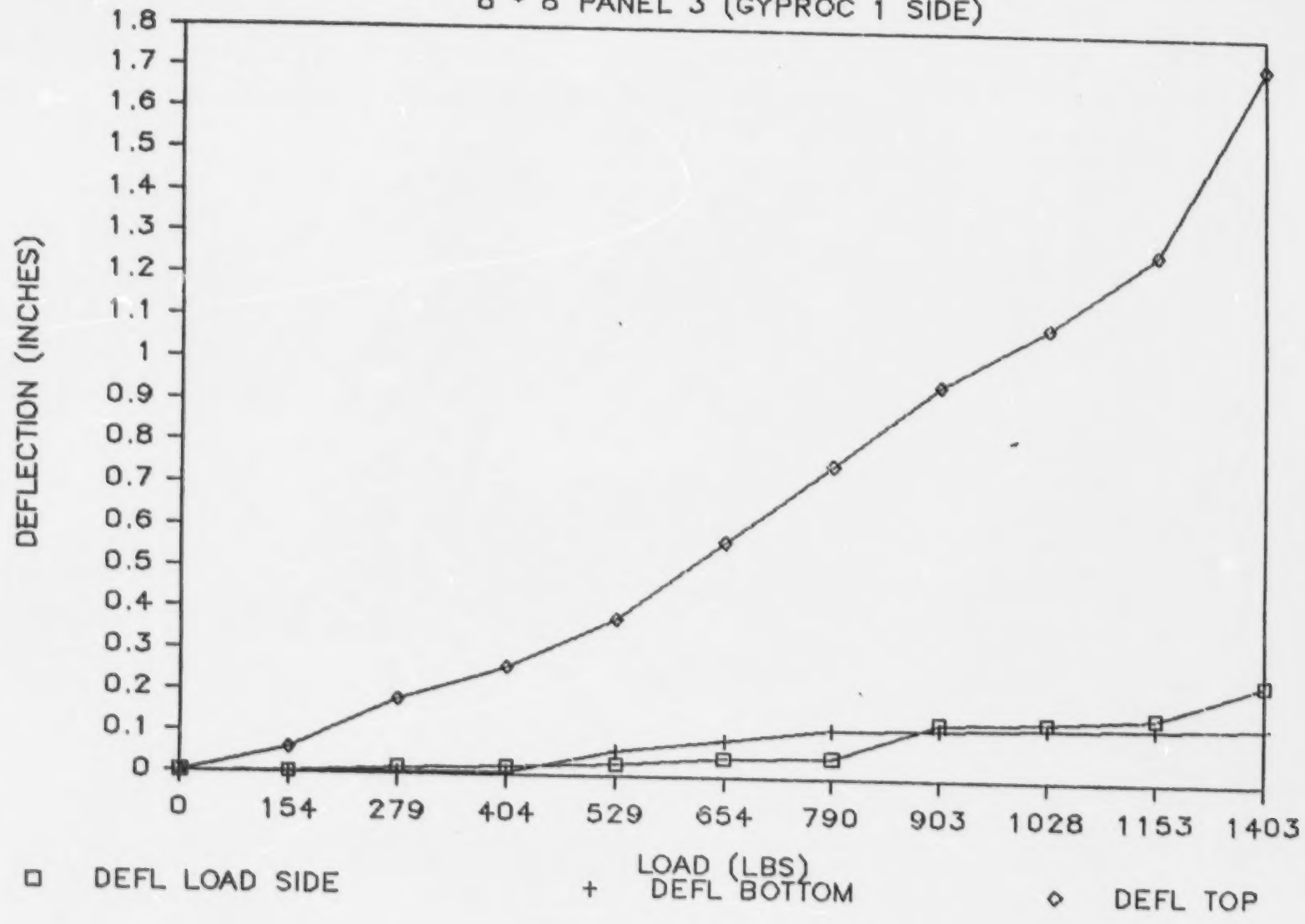
8 * 8 PANEL 1 (GYPROC 1 SIDE)



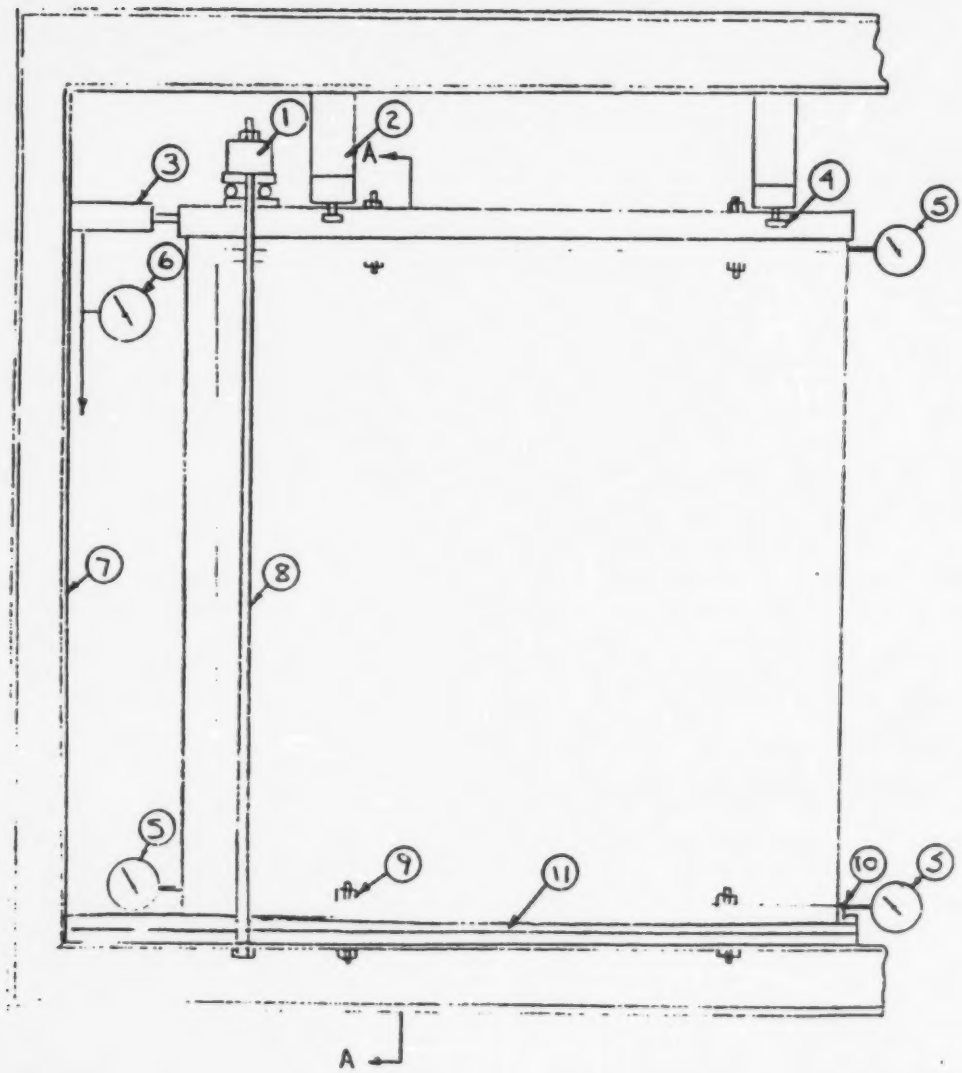

RACKING SHEAR TEST
8 * 8 PANEL 2 (GYPROC 1 SIDE)
DEFLECTION (INCHES)
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
154
279
404
529
654
790
903
1028
1153
1403
LOAD (LBS)
DEFL LOAD SIDE
DEFL BOTTOM
DEFL TOP

RACKING SHEAR TEST

8 * 8 PANEL 3 (GYPROC 1 SIDE)



RACKING SHEAR TEST DIAGRAM



SECTION A-A

1. Hold down plate and roller
2. Lateral Guides
3. Hydraulic Ram
4. Roller
5. Dial Micrometer
6. Calibrated Hydraulic Gauge
7. Reaction Frame
8. Hold down rod
9. Bolts
10. Stop
11. 2 x 12 Timbers

Wamock Hersey Professional Services Ltd.
211 Schoolhouse St., Coquitlam, B.C. V3K 4X9 - (604) 520-3321 - Telex 04-351404

REPORT OF: Physical Tests

AT: Coquitlam Laboratory

DATE August 22, 1987

PROJECT: 50489 C7 457900

REPORT NO. 3/87

REPORTED TO: Cano Structures Inc.,
7803P 35th Street, S. E.
Calgary, Alberta
T2C 1V3

ORDER NO.

INTRODUCTION:

We have carried out Axial Load tests on Cano Structures Nascor II wall system described below. The tests were conducted in accordance with A. S. T. M. standard E 72-80. "Standard Methods of Conducting Strength Tests of Panels for Building Construction." Three tests samples were manufactured at Cano's plant in Calgary on July 7, 1987 and tested on July 20, 1987.

A fourth sample prepared at Cano's Langley B. C. Plant on August 17, 1987 was tested on August 22, 1987. The fourth panel was tested, since one of the panels tested on July 20, 1987 was defective. The two side columns were slightly longer than the two middle columns and as such the two side columns carried most of the applied axial load and the panel failed prematurely.

DESCRIPTION OF NASCOR II AXIAL LOAD TEST SPECIMEN

The Nascor II test specimen consisted of 5½" thick wall system measuring 10'-0" high by 6'-0" wide with four Nascor columns spaced at 24" o.c. The wall panel was filled with 5½" thick expaned polystyrene insulation infill panels between the columns. One 2"x6" bottom plate and a one 2"x6" top plate are screwed into the columns studs using 4-3" long No. 10 "Lo-Root" screws. All wood is graded S.P.F. # 2 and better.

The Nascor column was made with two 2"x4" # 2 S.P.F and better lumber studs face adhered to polystyrene core using Dural P.V.A. glue spread at a rate of 250 sq. ft. per gallon.

Tests were performed without any sheathing on the panels. The specimen was placed in the load/vertically and the load was applied through a steel beam and hydraulic rams with caliberated gauge. The deflections were measured using dial indicators with .001" divisions.

At each increment of the load, the lateral deflection and set at the center of the wall and vertical deflection were recorded and tabulated.

...../2

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TEST RESULTS

	PANEL NOS.				
	1*	2	3	4	Average
Ultimate Load (lbs.)	18366	28035	31819	23915	27923
Ultimate Load (lbs/stud col.)	4591	7008	7954	5979	6980
Allowable Ultimate Load (lbs./stud) with safety factor of 3.	1530	2336	2651	1993	2327
Lateral Deflection (ins.) of the wall at centre at maximum allowable axial load.	-	0.06	0.020	0.04	0.04

* Results of Sample no. 1 have been omitted from the average due to defective test sample.

MODES OF FAILURE:

Sample No. 1	-	Two side columns buckled laterally parallel to the plane of the wall.
Sample No. 2	-	Wall buckled laterally perpendicular to the plane of the wall.
Sample No. 3	-	Wall buckled laterally perpendicular to the plane of the wall.
Sample No. 4	-	Wall buckled laterally perpendicular to the plane of the wall.

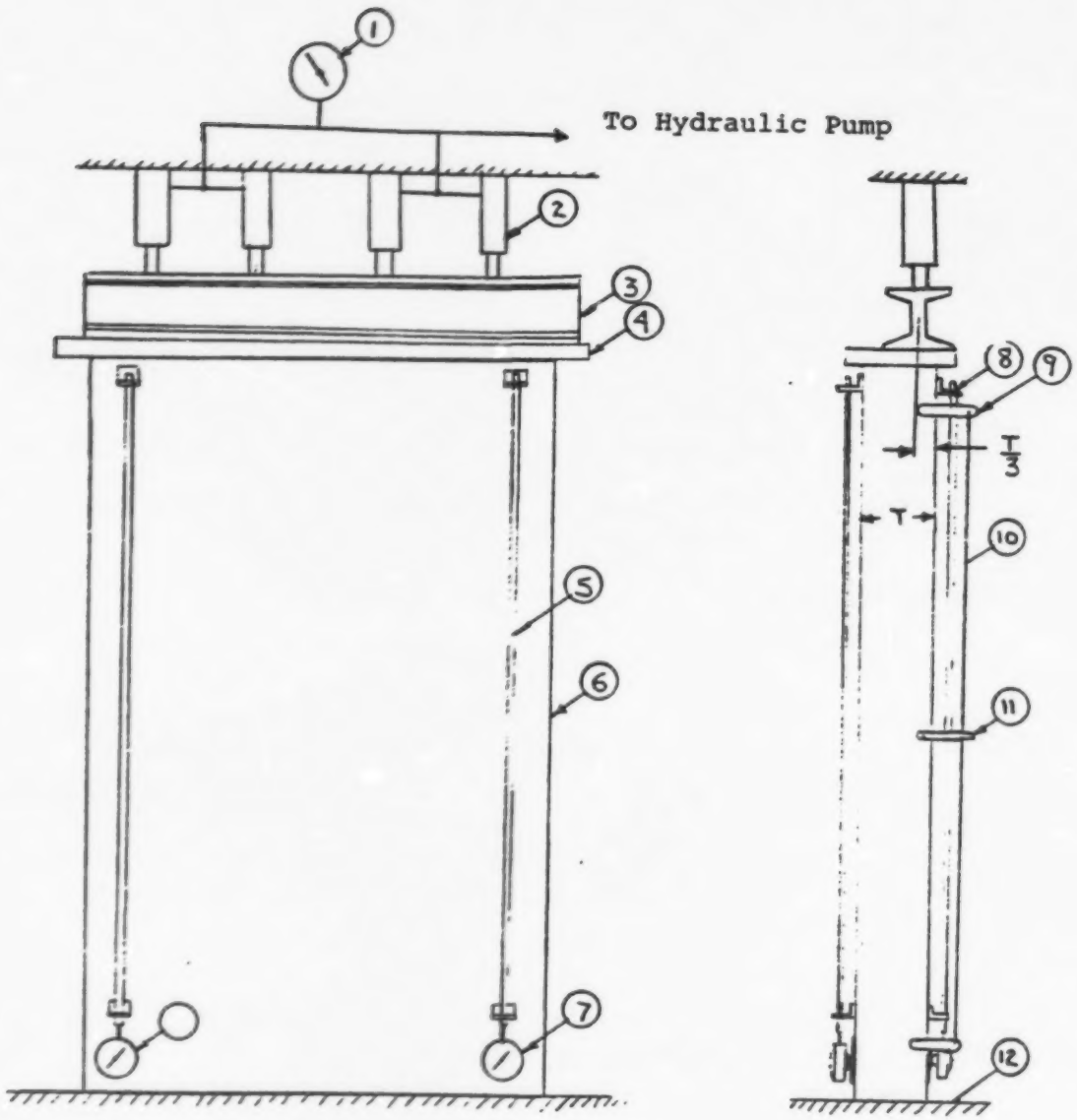
WARNOCK HERSEY PROFESSIONAL SERVICES LTD.

F. Mawani

F. Mawani, P. Eng.,
Manager, Field Services.

fm

AXIAL LOAD TEST DIAGRAM



1. Calibrated Pressure Gauge
2. Hydraulic Rams
3. 4" x 48" I Beam
4. 1/4" x 6" x 48" steel plate
5. Steel Rod
6. Test Specimen 48 x 96
7. Dial Micrometers (4)
8. L. Bracket
9. Wire Clamp
10. Wire
11. Deflectometer
12. Reaction Frame

Warnock Hersey Professional Services Ltd.

AXIAL LOAD TEST DATA.

LOAD - GAUGE READING. PSI.	LOAD. LBS.	DEFLECTIONS. - LATERAL. (mm.). T=0	T=5	LOAD RELEASED.
0	0	103	-	-
300	700	103	-	-
500	1549	102	102	102
750		102	102	101.5
1000	3651	101.5	101.5	101.5
1250		102	102	102
1500		101.5	102	102
1750		102	102	102
2000	7855	102	102	102
2250		102	102	102
2500		102	102	102
2750		102	102	102
3000	12059	102	102	102

Two side panels were longer than the middle panels.
lateral deflection of side panels parallel to the plane of the wall noticed. Maximum Load recorded = 4500 psi.

= 18366 Lbs.

SAMPLE NO: 1
SAMPLE DIMENSIONS: 10' x 6' x 4 Columns.
PRE-LOAD: 700 Lbs.

DATE TESTED: JULY 20 1987.

AXIAL LOAD TEST DATA.

LOAD - GAUGE READING. PSI.	LOAD. LBS.	DEFLECTIONS. - LATERAL. (mm.) T=0	T=5	LOAD RELEASED.
300	700	49	-	-
750		49	49	49
1000	3651	49	48.5	49
1500		48.5	48.5	49
2000	7855	48.5	48.5	49
2500		48.5	48.5	49
3000	12059	48.5	48.5	48.5
3500		48.5	48.5	48.5
4000	16264	48	48	48.5
4500		47	47	48.5
5000	20468	47	-	48.5
5500		46.5	-	48.5
6000	24672	45	-	-

Maximum = 7700 psi. =31819 lbs.

Failure by buckling in the plane perpendicular to thwall.

SAMPLE NO: 2.
SAMPLE DIMENSIONS: 10' x 6' x 4Columns.
PRE-LOAD: 700 Lbs.

DATE TESTED: JULY 20 1987.

AXIAL LOAD TEST DATA.

LOAD - GAUGE READING. PSI.	LOAD. LBS.	DEFLECTIONS - LATERAL. (mm.) T=0	T=5	LOAD RELEASED.
300	700	47	-	-
500	1549	47	47	47
750		46.5	46.5	47
1000	3651	46.5	46.5	47
1250		46.5	46.5	47
1500		46	46	47
2000	7855	46	46	47
2500		45.5	45.5	-
3000	12059	45.5	45.5	47
3500		45	45	46.5
4000	16264	44.5	44.5	46
4700		43	42.5	46
5000	20468	42	41	46

Maximum = 6800 psi. =28035 lbs.

Failure by buckling in the plane perpendicular the wall.

SAMPLE NO: 3.
SAMPLE DIMENSIONS: 10' x 6' x 4 Columns.
PRE-LOAD: 700 Lbs.

DATE TESTED: 20 JULY 1987.

AXIAL LOAD TEST DATA.

LOAD - GAUGE READING. PSI.	LOAD. LBS.	DEFLECTIONS. - LATERAL. (Ins.) T=0	T=5	LOAD RELEASED.
300	700	0	-	-
750		.008	.009	-.001
1000	3651	.012	.013	-.008
1250		.020	.020	-.006
1500		.025	.025	-.005
1750		.032	.032	-.005
2000	7855	.037	.038	-.005
2500		.052	.052	-.006
3000	12059	.064	.066	-.005
3500		.078	.081	-.004
4000	16264	.107	.112	-.002
4500		.153	.172	+.008
500	24672	.172	.220	+.036

Maximum = 5700 psi. = 23915 Lbs.

Failure by buckling in the plane perpendicular to the wall.

SAMPLE NO: 4
SAMPLE DIMENSIONS: 10' x 6' x 4 Columns.
PRE-LOAD: 700 Lbs.

DATE TESTED: AUGUST 22 1987.

APPENDIX D

WARNOCK HERSEY LETTER DESCRIBING

RESULTS OF FIRE RESISTANCE TEST

FIRE LABORATORIES DIVISION

Warnock Hersey Professional Services Ltd.
211 Schoolhouse Street, Coquitlam, B C V3K 4X9
Tel (604) 520-3321 Telex 04-351404

July 14, 1986

Cano Structures Ltd.
7803P - 35th Street S.E.
Calgary, Alberta
T2C 1V3

Attention: David Burnes, P. Eng.

Dear Sir:

On Tuesday, June 10, 1986, we conducted a fire resistance test on a submitted NASCOR ™ R-20 wall system which was 9'0 high, 14'0 long and 5 1/2" thick. The sample partition was faced on each side with one layer of 5/8" thick fire rated gypsum wallboard (taped and filled). The 2 x 4's in the columns of this partition were interconnected using three dowels (one near the top, one near the bottom, and one at midheight).

Testing was conducted in accordance with CAN4-S101 Standard for Fire Endurance Testing of Building Components, for a one hour rating.

The attached observation chart is for your information. The partition began to loose its ability to support the applied load (2000 lbs. per linial foot) at 39:25 minutes. Post test inspection of the partition revealed that the dowel concept was unsuccessful because charring occurred at the dowel/stud interface resulting in freedom of movement (bowing), of the walls. Once the exposed face stud deqenerated sufficiently to result in a non-symmetric system the partition failed.

Yours truly,

WARNOCK HERSEY PROFESSIONAL SERVICES LTD.

H Grisack.

Howard A. Grisack, A.Sc.T.
Manager
Western Region

HAG:llw 07-16

CLIENT: CANO STRUCTURES INC. DATE: 86-06-10

TEST SPECIMEN DESCRIPTION: LOAD BEARING WALL

TIME :MIN:SEC.	EXPOSED	UNEXPOSED
1:24	ignition of drywall face	
2:00	paper burned off completely	
7:00	N/C	smoke lower right (grey) side when drywall ends
17:00	drywall cement fallen off at joints and screw locations	smoke & water vapour venting at lower right side
21:00	studs flaming at exposed joints- cracking & snapping	smoke continues to vent at right edge & at several points across top.
27:00		wall bowing visibly out of furnace
31:00	bowing visible flaming at studs at drywall joints	grey smoke venting at both top corners
37:00	foam burning on sill at base of studs at drywall joints	smoke continuing to vent at top corners
39:25	load not holding	
40:35	Fire Endurance Test - discontinued.	

APPENDIX E

WARNOCK HERSEY TEST REPORT ON

SCREWS AND ADHESIVES

Warnock Hersey Professional Services Ltd.
211 Schoolhouse St., Coquitlam, B.C. V3K 4X9 - (604) 520-3321 - Telex 04-351404

REPORT OF: Physical Tests

AT: Coquitlam Laboratory

DATE June 29, 1987

PROJECT: 50489 C7 457900

REPORT NO. 1/87

REPORTED TO: Cano Structures Inc.
7803P 35th Street, S.E.
Calgary, Alberta
T2C 1V3

ORDER NO.

INTRODUCTION:

As requested, we have carried out Lateral Resistance and Screw Withdrawal Resistance Tests on samples of "Lo-Root" No. 10 wood screws submitted by Cano Structures Inc.

Tests were carried out in accordance with A.S.T.M. Standard D1761 - "Mechanical Fasteners in Wood".

TEST RESULTS:

1. Lateral Resistance in Spruce Pine Fir

SAMPLE NO.	LATERAL RESISTANCE	MODE AT FAILURE
1	378 lbs.	Screw sheared
2	330 lbs.	Screw sheared
3	393 lbs.	Head pulled through
4	489 lbs.	Screw sheared
5	411 lbs.	Screw sheared
6	418 lbs.	Screw sheared
7	438 lbs.	Screw sheared
Average	408 lbs.	

Allowable lateral resistance per screw based on safety factor of 6 + 10%

.../2

$= \frac{408}{6} \times 1.1 = 75$ lbs.

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FORM 119-CE-80-E

TEST RESULTS: Continued

2. Screw Withdrawal Perpendicular to Grain Spruce Pine Fir

SAMPLE NO.	WITHDRAWAL RESISTANCE
1	1008 lbs.
2	1182 lbs.
3	1176 lbs.
4	1203 lbs.
5	1156 lbs.
Average	1145 lbs.

3. Screw Withdrawal Parallel to Grain Spruce Pine Fir

SAMPLE NO.	WITHDRAWAL RESISTANCE
1	830 lbs.
2	855 lbs.
3	826 lbs.
4	875 lbs.
5	840 lbs.
Average	845 lbs.

WARNOCK HERSEY PROFESSIONAL SERVICES LTD.

F. Mawani

F. Mawani, P. Eng.,
Supervising Engineer
Field Inspections & Physical Testing

FM/tr/87.06.29

480.D4.PC.

Warnock Hersey Professional Services Ltd.
211 Schoolhouse St., Coquitlam, B.C. V3K 4X9 - (604) 520-3321 - Telex 04-351404

REPORT OF: Physical Tests

AT: Coquitlam Laboratory

DATE August 22, 1987

PROJECT: 50489 C7 457900

REPORT NO. 2/87

REPORTED TO: Cano Structures Inc.
7803P 35th Street, S.E.
Calgary, Alberta,
T2C 1v3

ORDER NO.

INTRODUCTION:

We have carried out additional Lateral Resistance tests on samples of "Lo-Root" 3 inch and 5 inch No. 10 wood screws submitted by Cano Structures Inc. Lateral Resistance values of screws in S.P.F. grade lumber were determined, for penetration into the end grain.

TEST DATA:

Moisture Content of Lumber	16%
Specific Gravity of Lumber	0.42
Depth of Penetration of the screw in the member receiving point(i.e. into the end grain)	1½"

TEST DESCRIPTION

See enclosed sketches.

TEST RESULTS:

1. Lateral Resistance in Spruce Pine Fir Lumber - 3" Screws

SAMPLE NO.	LATERAL RESISTANCE	MODE AT FAILURE
1	496 lbs.	Wood Failure in Cross Member
2	589 lbs.	Wood Failure in Cross Member
3	545 lbs	Wood Failure in Cross Member
4	290 lbs	Wood Failure in Cross Member
5	567 lbs.	Wood Failure in Cross Member
Average	497 lbs.	

.....1/2

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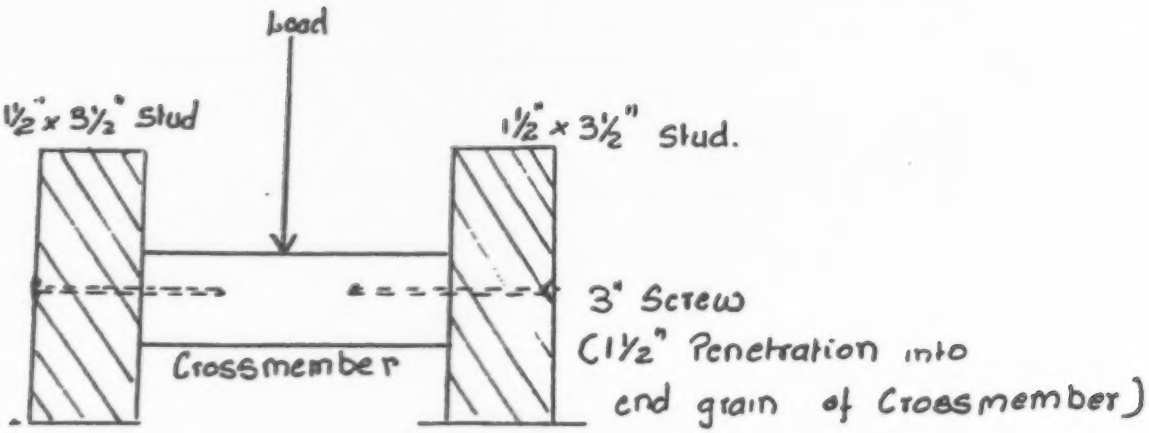
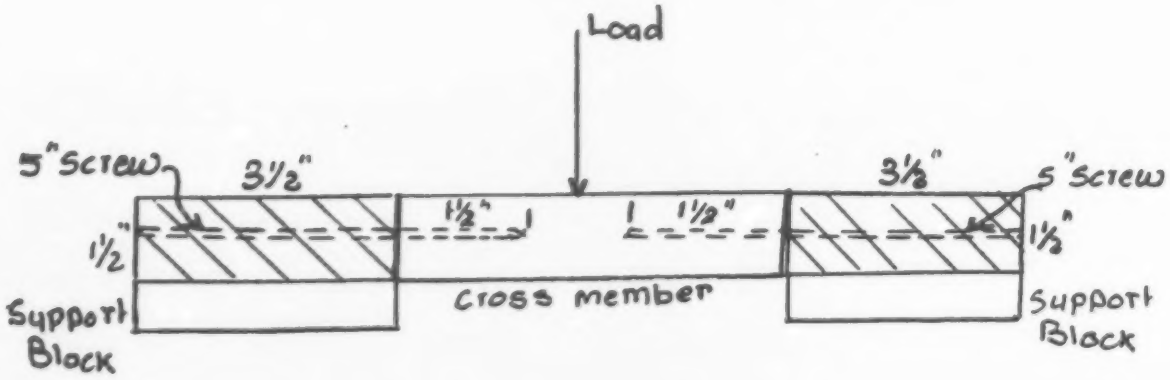


Test set up for 3" Screw.



Test set up for 5" Screw

TEST RESULTS: Continued

Allowable Lateral Resistance per 3" screw drive 1½" into the end grain of S.P.F. lumber based on safety factor 6 = 10% criteria.

$$+ \frac{497}{6} \times 1.1 = 91 \text{ lbs.}$$

2. Lateral Resistance in Spruce Pine Fir Lumber - 5" Screws

SAMPLE NO.	LATERAL RESISTANCE	MODE OF FAILURE
1	392 lbs.	Wood Failure in Cross Member
2	485 lbs.	Wood Failure in Cross Member plus 1 screw sheared off.
3	404 lbs.	Wood Failure in Cross Member
4	477 lbs.	Wood Failure in Cross Member
5	324 lbs.	Wood Failure in Cross Member
6	348 lbs.	Wood Failure in Cross Member
Average	405 lbs.	

Allowable Lateral Resistance per 5" screw driven 1½" into the end grain of S.P.F. Lumber based on safety factor of 6+10% criteria.

$$= \frac{405}{6} \times 1.1 = 74 \text{ lbs.}$$

Warnock Hersey Professional Services Ltd.,

F. Mawani

F. Mawani, P. Eng.
Manager,
Field Inspections & Physical Testing

fm

Warnock Hersey Professional Services Ltd.
211 Schoolhouse St., Coquitlam, B.C. V3K 4X9 - (604) 520-3321 - Telex 04-351404

REPORT OF: Physical Tests

AT: Coquitlam Laboratory

DATE June 29, 1987

PROJECT: 50489 C7 457900

REPORT NO. 2/87

REPORTED TO: Cano Structures Inc.
7803P 35th Street, S.E.
Calgary, Alberta
T2C 1V3

ORDER NO.

INTRODUCTION:

As requested, we have carried out Comparative Shear Tests on two types of glues used to bond polystyrene core to 2" x 4" nominal size Spruce Pine Fir specie studs.

TEST METHOD

Four inch long specimen of studs with polystyrene core bonded between two studs in flat orientation i.e. to 3 1/2" face were tested by compression loading.

The test specimen was supported on a shear jig and a compressive load was applied to the styrene core at a rate to obtain failure in approximately five minutes. Maximum load required to achieve failure for the four inch long specimen was recorded.

The following two types of glues were used:

1. Dural PVA White Glue

2. Morton Thiokol Inc. MOR-AD 336.

.../2

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FORM 119-CE-80-E

TEST RESULTS:

1. Average force required to achieve failure in four inch long specimen bonded with Dural PVA White Glue

   = 148 lbs. (Average of 140 specimens)

2. Average force required to achieve failure in four inch long specimen bonded with MOR-AD 336 Glue

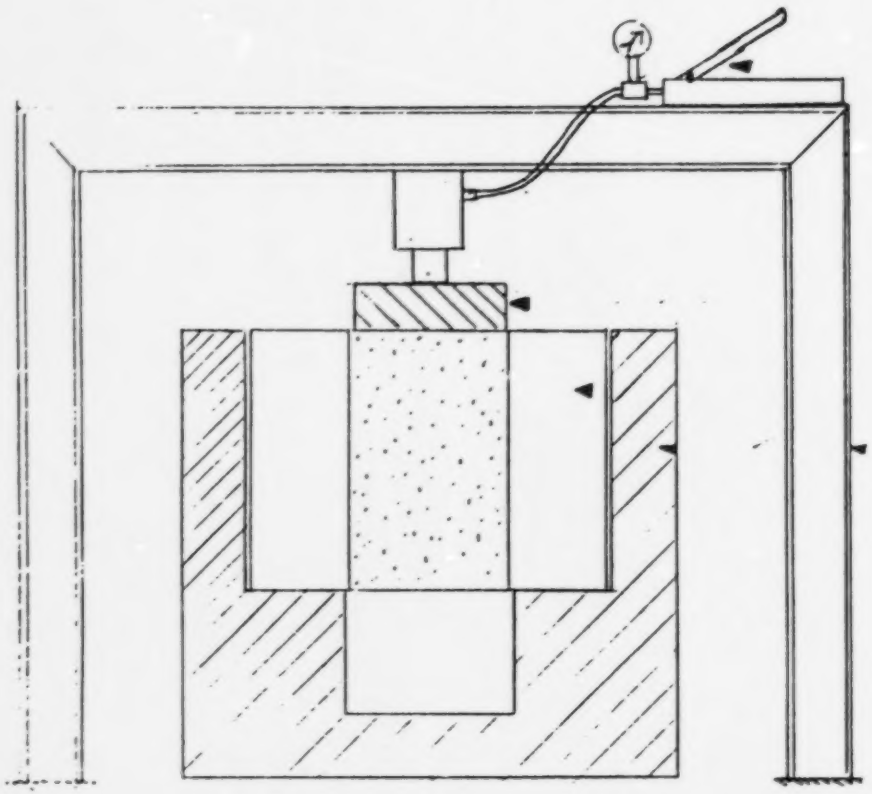
   = 166 lbs. (Average of 80 specimens).

WARNOCK HERSEY PROFESSIONAL SERVICES LTD.

F. Mawani, P. Eng.,
Supervising Engineer
Field Inspections & Physical Testing

FM/tr/87.06.29

480.D4.PC.



CLIENT CANO STRUCTURES INC.

PROJECT 50489 C7 457900

PARTICULARS SHEAR TEST SET UP.

Warnock Hersey

RECEIVED AUG 14 1986

Warnock Hersey Professional Services Ltd.
211 Schoolhouse Street, Coquitlam, B.C. V3K 4X9 Tel: (604) 520-3321 Envoy WPM 8076

August 6, 1987

I.C.B.O. Evaluation Service, Inc.
5360 South Workman Mill Road
Whittier, CA 90601

Attention: Mr. R. Krivchuk, P.E.

Dear Mr. Krivchuk

RE: CANO STRUCTURES INC. FILE NO. 87-9-5

Herewith please find the additional information you requested with regards to our testing on Glue Comparison Tests and Lateral Capacity of 3" screws used by Cano Structures Inc.

1. Glue Comparison Test

	Dural PVA White Glue	Morton Thiokol Inc. Morad 336
1. Rate of Glue Spread	250 sq.ft./gal.	250 sq.ft./gal.
2. Density of Polystyrene lbs/cu.ft.	0.90 - 0.97	0.90 - 0.9L
3. Moisture contact of S.P.F. studs*	8% to 15%	8% to 15%

In approximately 90% of the sample, the failure was in the polyshrene. The failure mode for each sample was not recorded.

* Checked on random samples.

.../2

2. Lateral Resistance of "Lo-Root" No. 10 Wood Screws

   1. Specific Gravity of S.P.F. lumber = 0.41

   2. Moisture Kiln Dried Content of S.P.F. lumber = 8.25 %

   3. Depth of penetration of the screw = Length of the threaded portion - 2"

Also, please find enclosed additional information from CANO Structures Inc.

Yours truly,

WARNOCK HERSEY PROFESSIONAL SERVICES LTD.,

F. Mawani

Farid Mawani, P. Eng.,
Manager,
Field Inspections & Physical Testing

FM/mg 87-08-06

Encl.

APPENDIX F

ICBO EVALUATION SERVICE INC.

EVALUATION REPORT #4491

ICBO Evaluation Service, Inc.
A subsidiary corporation of the International Conference of Building Officials

EVALUATION REPORT

Report No. 4491
September, 1987

Filing Category: ROOF, WALL AND FLOOR PANELS—Wood

NASCOR I AND NASCOR II R-20 WALL SYSTEMS
CANO STRUCTURES, INC.
7803 P 35TH STREET, S.E.
CALGARY, ALBERTA, CANADA T2C 1V3

I. **Subject:** NASCOR I and NASCOR II R-20 Wall Systems.

II. **Description:** A. **General:** NASCOR wall systems are factory-assembled exterior load-bearing wall panels of wood framing and expanded polystyrene (EPS) foam plastic infill panels. Panel lengths vary up to 16 feet. The lumber grade and species comply with Table No. 1. Foam plastic consists of BASF Wyandotte, Inc., BF-322 polystyrene beads, recognized in Evaluation Report No. 3401, expanded to a nominal density of 1.0 pound per cubic foot to the thickness noted in this report.

B. **NASCOR I Wall System:** 1. **General:** NASCOR I Wall System panels consist of wood studs conventionally oriented and factory installed into 1½-inch-wide by 3½-inch-deep notches on the interior wall face of 4½-inch-thick EPS foam plastic infill panels. See Figure No. 1. The wood studs are spaced at 12, 16 or 24 inches on center and adhered to the infill panels with Morton Chemical Corporation Mor-Ad 336 adhesive recognized in Evaluation Report No. 3462. The foam plastic infill width is the same as the stud spacing. A 1½-inch-square foam plastic spline is friction fitted into vertical and horizontal splices of the infill panels. Each infill panel has a 5/16-inch-deep by 1½-inch-wide vertical groove on the exterior face at each stud location to facilitate installation of exterior finishes. A 1-inch-wide by 1¾-inch-deep horizontal electrical keyway is cut into the interior face of the infill panels 24 inches from the bottom. The wood studs are drilled in the field at the electrical keyway with the bored holes conforming to Section 2517 (g) 9 of the code.

Single 2 by 4 top and bottom plates are factory attached to each wood stud with two No. 10 by 3-inch-long wood screws.

Lintels at wall openings consist of a ½-inch-thick EPS core and 2 by 10 or 2 by 12 wood facings laminated with an adhesive and two rows of 16-penny common nails spaced at 16 inches on center. One 2 by 4 full height stud and one 2 by 4 cripple stud fastened together with No. 10 by 3-inch-long wood screws spaced at 24 inches on center are used at each jamb. Lintel ends are attached to the full height studs with four No. 10 by 3-inch-long wood screws. Each end of 2 by 4 wood sills are attached to the wall opening studs with three No. 10 by 3-inch-long wood screws.

One-inch-thick foam plastic fillers furnished with panels are field installed on the exterior face of the panels at the top plate, bottom plate, lintels, and wall corners. The foam plastic is the same as the EPS foam plastic infill panels.

2. **Design:** NASCOR I wall panels are considered conventional construction in accordance with Section 2517 (g) of the code. Sufficient calculations and details must be furnished to the building official indicating compliance. Maximum load bearing, and nonload bearing laterally unsupported wall heights are 10 and 14 feet, respectively, as specified in Table No. 25-R-3 of the code. Multiple studs in the wall panels at girder supports must be designed and constructed in accordance with the code.

3. **Installation:** Wall panels are lifted into place and interlocked by sliding the panels together with the factory-installed spline on one end of the panel pressed into the slot of the adjacent panel. A 2 by 4 wood cap plate is attached with 16-penny nails spaced at 16 inches on center. The cap plate must have a minimum 48-inch lap length and overlap panels at wall corners. Wall panels are toenailed to floor joists or 2 by 4 wood plates with 16-penny nails spaced at 10 inches on center. Plates comply with Section 2516 (c) 3 of the code and are installed in accordance with Section 2517 (b). See Figure No. 5.

The interior wall finish of ½-inch-thick gypsum wallboard is installed in accordance with Section 4711 of the code.

The foam plastic filler pieces supplied with the wall panels are attached to the exterior face of the wood framing with No. 16 gauge by 2-inch-long galvanized staples having a 7/16-inch-wide crown spaced at 16 inches on center.

A weather-resistive barrier must be installed on the exterior face of panels in accordance with Section 1707 (a) of the code. Exterior finish or exterior plaster is installed in accordance with Section 2516 (g) and 4708, respectively, except 1-inch longer fasteners are used.

C. **NASCOR II R-20 Wall System:** 1. **General:** NASCOR II R-20 Wall System panels consist of 5½-inch-thick expanded polystyrene (EPS) foam plastic infill panels and vertical framing elements identified as columns. See Figure No. 2. Columns consist of an expanded polystyrene foam plastic core and two 2 by 4 wood studs laminated with Morton Chemical Corporation Mor-Ad 336 adhesive and fastened together with 5-inch-long nails spaced 18 inches on center. See Figure No. 4. The infill panel widths are 8½, 12½ and 20½ inches for column spacings of 12, 16 and 24 inches, respectively. A 1½-inch-square foam plastic spline is friction fitted into the joint between the infill panel and column. The interior face of the infill panel has a 1-inch-wide by 1¾-inch-deep horizontal electrical keyway located 24 inches from the bottom of the wall panel. The EPS core of the columns has a horizontal 1-inch-wide by ½-inch-deep notch behind the 2 by 4 stud to provide the wall panel with a continuous horizontal electrical keyway.

Lintels at wall openings consist of a 2½-inch-thick foam plastic core and two 2 by 10 or 2 by 12 wood members laminated with an adhesive and two rows of 40-penny common spiral nails at 16 inches on center. Lintels are supported by a 2 by 6 cripple stud at each end. A full-height end post is installed adjacent to each cripple stud. Cripple studs are attached to the adjacent full-height end post with No. 10 by 3-inch-long wood screws spaced at 16 inches on center. End posts are the same as the previously described columns except the polystyrene core of the end post has only one longitudinal notch to receive the foam plastic spline.

End posts are attached to each wood member of the lintel with two No. 10 by 5-inch-long wood screws. Ends of 2 by 6 sills are attached to the cripple studs with three No. 10 by 3-inch-long wood screws. See Figure No. 3.

Single 2 by 6 top and bottom plates are factory attached to each stud of each column and end post with two No. 10 by 3-inch-long wood screws. The bottom plate is attached to each cripple stud with three screws.

2. **Design:** Allowable loads for the NASCOR II R-20 wall panels are specified in Table No. II. The exterior wall finish must resist required wind loads perpendicular to the wall plane. Wall opening headers and cripple studs are designed in accordance with the code. Sills are designed in accordance with the code. The sill-to-cripple-stud connection has a maximum load capacity of 182 pounds. The racking shear capacity of the wall panels having ½-inch-thick gypsum wallboard attached to the interior face of each column with 1⅝-inch-long drywall screws spaced at 12 inches on center is 38 pounds per lineal foot of wall. The maximum allowable shear wall height-to-length ratio is 1½ to 1. Plans and calculations for each project showing compliance with this report must be submitted to the building official for approval. Multiple studs at girder supports and their connections must be designed and constructed in accordance with the code.

Evaluation reports of ICBO Evaluation Service, Inc., are issued solely to provide information to Class A members of ICBO, utilizing the code upon which the report is based. Evaluation reports are not to be construed as representing aesthetics or any other attributes not specifically addressed nor as an endorsement or recommendation for use of the subject report.

This report is based upon independent tests or other technical data submitted by the applicant. The ICBO Evaluation Service, Inc., technical staff has reviewed the test results and/or other data, but does not possess test facilities to make an independent verification. There is no warranty by ICBO Evaluation Service, Inc., express or implied, as to any "Finding" or other matter in the report or as to any product covered by the report. This disclaimer includes, but is not limited to, merchantability.

3. **Installation:** Wall panels are lifted into place and interlocked by sliding panels together with the factory-installed spline on one end of the panel pressed into the slot of the adjacent panel. A 2 by 6 wood cap plate is field installed and panels are attached to the floor in accordance with approved plans. See Figure No. 5.

The interior wall finish of ½-inch-thick gypsum wallboard is installed in accordance with Section 4711 of the code.

A weather-resistive barrier must be installed on the exterior face in accordance with Section 1707 (a) of the code. Exterior finishes or exterior plaster are installed in accordance with Sections 2516 (g) and 4708, respectively, of the code.

D. **Identification:** The interior face of each polystyrene infill panel is identified with the word "NASCOR," the manufacturer's name and the evaluation report number. The NASCOR I field-installed expanded polystyrene filler pieces are packaged in plastic bags bearing the manufacturer's name and address. Additionally, each wall panel, each package of NASCOR I polystyrene filler pieces and each NASCOR II R-20 column and end post of each wall panel has a label bearing the manufacturer's name, evaluation report number, and the name of the quality control agency (Warnock Hersey Professional Services Ltd., NER-QA 219).

III. **Evidence Submitted:** Report of transverse, axial and racking shear tests of NASCOR II R-20 wall panels and quality control manuals.

Findings

IV. Findings: That the NASCOR I and NASCOR II R-20 Wall Systems described in this report comply with the 1985 Uniform Building Code, subject to the following conditions:

1. **The wall panels are fabricated and installed in accordance with this report and the manufacturer's instructions.**
2. **Plans and calculations are submitted to the local building official justifying that NASCOR II R-20 wall panel loads, based on the building design, do not exceed allowable loads in this report.**
3. **The remaining portions of the structure are designed and constructed in accordance with the code.**
4. **Exterior wall panels are provided with a complying weather-resistive barrier and wall covering complying with the code.**
5. **The panels are limited to Type V-N construction.**
6. **Electrical and plumbing installations are not a part of this report and require approval by the building official.**
7. **The wall panels are fabricated at the Calgary, Alberta, Canada, facility with quality control follow-up inspections by Warnock Hersey Professional Services Ltd., NER-QA 219.**

This report is subject to re-examination in one year.

TABLE NO. I—WOOD MEMBER DESCRIPTIONS

COMPONENT	SIZE (Inches)	LENGTH (Inches)	SPECIES AND GRADE[1]
NASCOR I studs, cripple studs, and corner posts	2 by 4	92⅝	Spruce-pine-fir stud grade[2]
		to 168 max	Spruce-pine-fir No. 1 or 2
NASCOR II—R-20 Columns and end posts	2 by 4	92⅝	Spruce-pine-fir stud grade[2]
		to 120 max	Spruce-pine-fir No. 1 or 2
NASCOR I Top plates, bottom plates, window sill plates and beam supports	2 by 4	Varies	Spruce-pine-fir No. 1 or 2
NASCOR II—R-20 Top plates, bottom plates, window sill plates, cripple studs and beam supports	2 by 6	Varies	Spruce-pine-fir No. 1 or 2
NASCOR I and II—R-20 Lintels	2 by 10 2 by 12	Varies	Spruce-pine-fir No. 1 or 2, or Douglas fir-larch No. 1 or 2

[1]All lumber is graded by Alberta Forest Products Association, Edmonton, Alberta, Canada, in accordance with grading rules of the National Lumber Grades Authority for Canadian lumber.

[2]Lumber is finger jointed and is graded in accordance with SPS 1, the National Lumber Grades Authority Special Products Standard for finger-jointed structural lumber.

TABLE NO. II—NASCOR II R-20 WALL PANEL ALLOWABLE LOADS[1]

WALL HEIGHT (Feet)	COLUMN SPACING (Inches)	AXIAL LOAD (Pounds per foot)	TRANSVERSE LOAD (psf)		
				DEFLECTION	
			STRESS	L/180	L/240
8	12	2,730	59.0	43.8	32.8
	16	2,047	44.3	32.9	24.7
	24	1,365	29.5	21.9	16.4
9	12	2,528	29.2	30.8	23.2
	16	1,896	21.9	23.1	17.4
	24	1,264	14.6	15.4	11.6
10	12	2,327	19.2	22.6	16.8
	16	1,745	14.5	17.0	12.6
	24	1,163	9.6	11.3	8.4

[1]Allowable loads for walls subjected to combined axial and transverse loads are determined by the ratio of actual axial load to allowable axial load, plus the ratio of actual transverse load to allowable transverse load not exceeding 1.00.

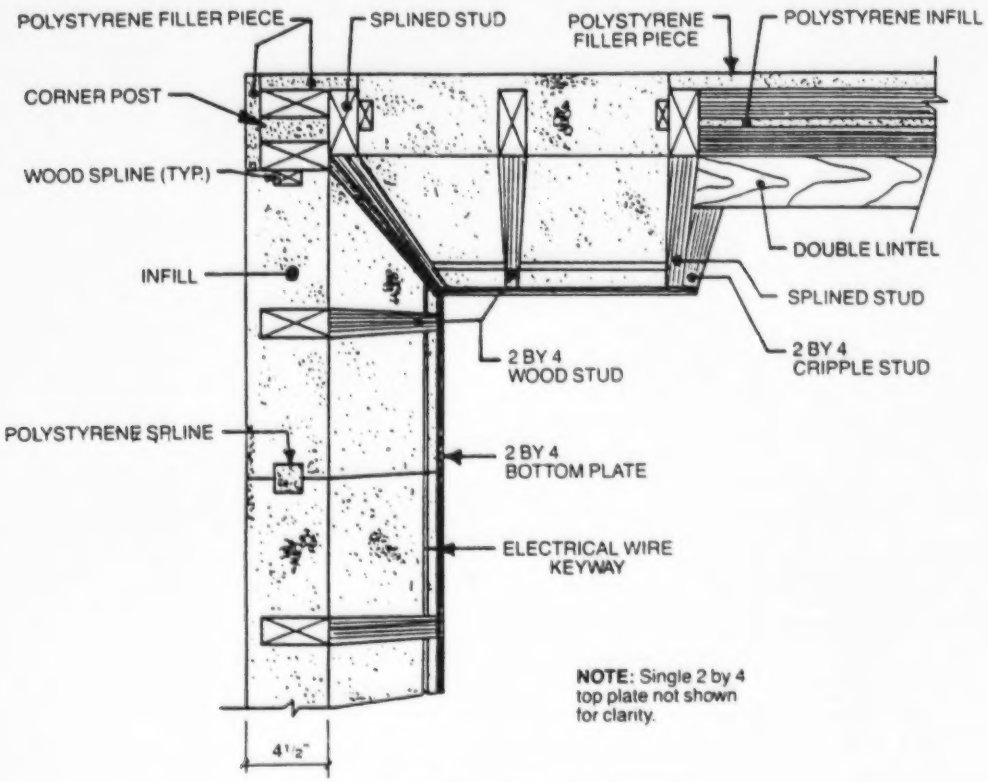
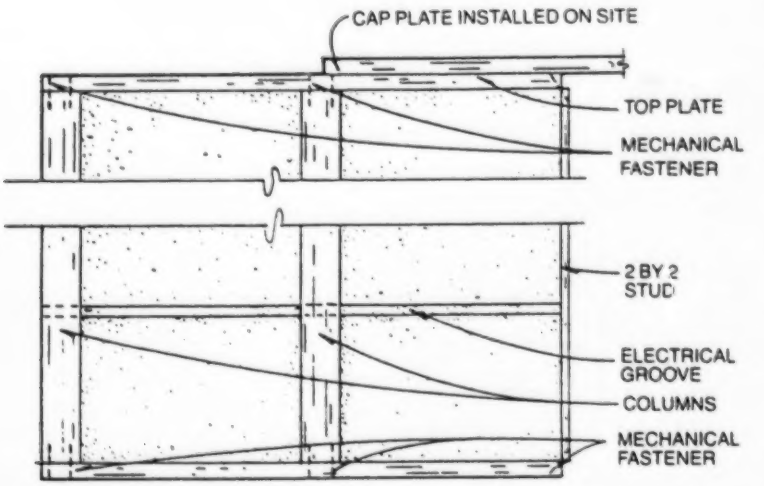
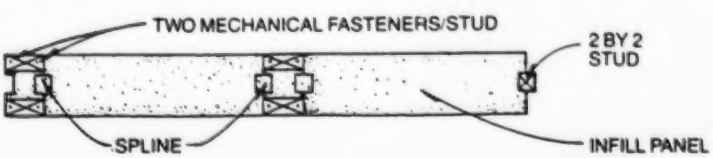


FIGURE NO 1—TYPICAL NASCOR I WALL PANELS—ISOMETRIC PLAN VIEW



TYPICAL WALL ASSEMBLY—ELEVATION



TYPICAL WALL ASSEMBLY—PLAN

FIGURE NO. 2—NASCOR II R-20 WALL PANEL

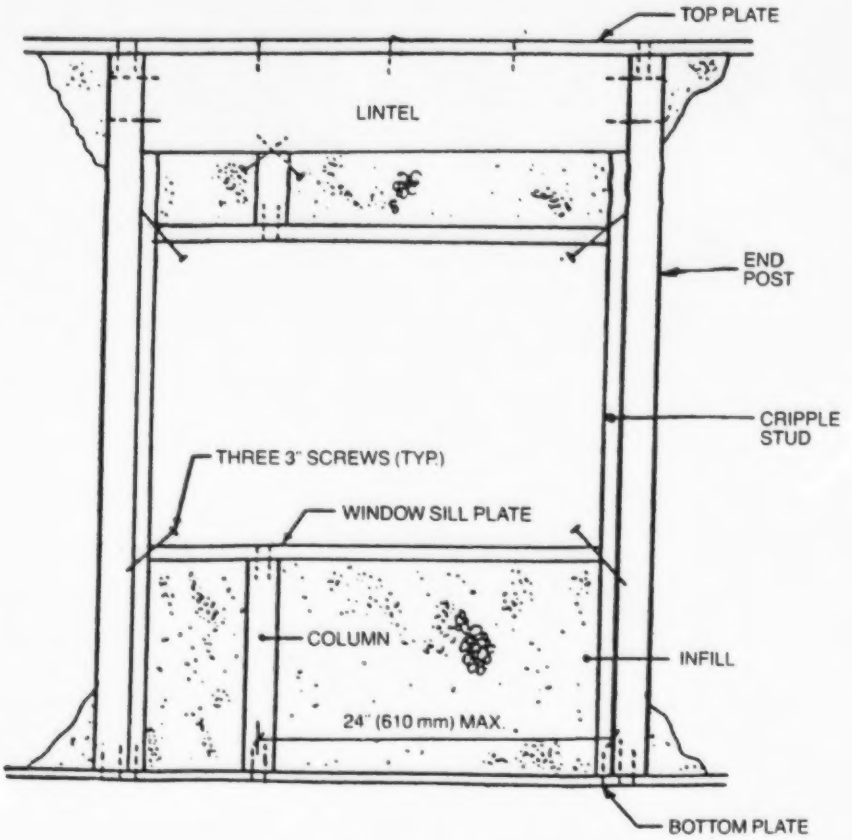


FIGURE NO. 3—NASCOR II R-20 TYPICAL WALL OPENING PANEL

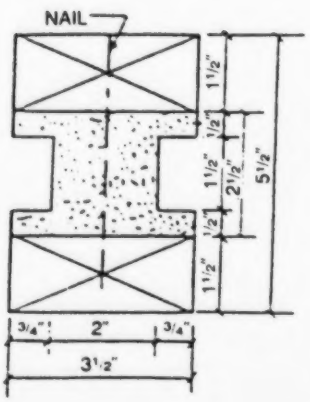


FIGURE NO. 4—TYPICAL NASCOR II R-20 COLUMN

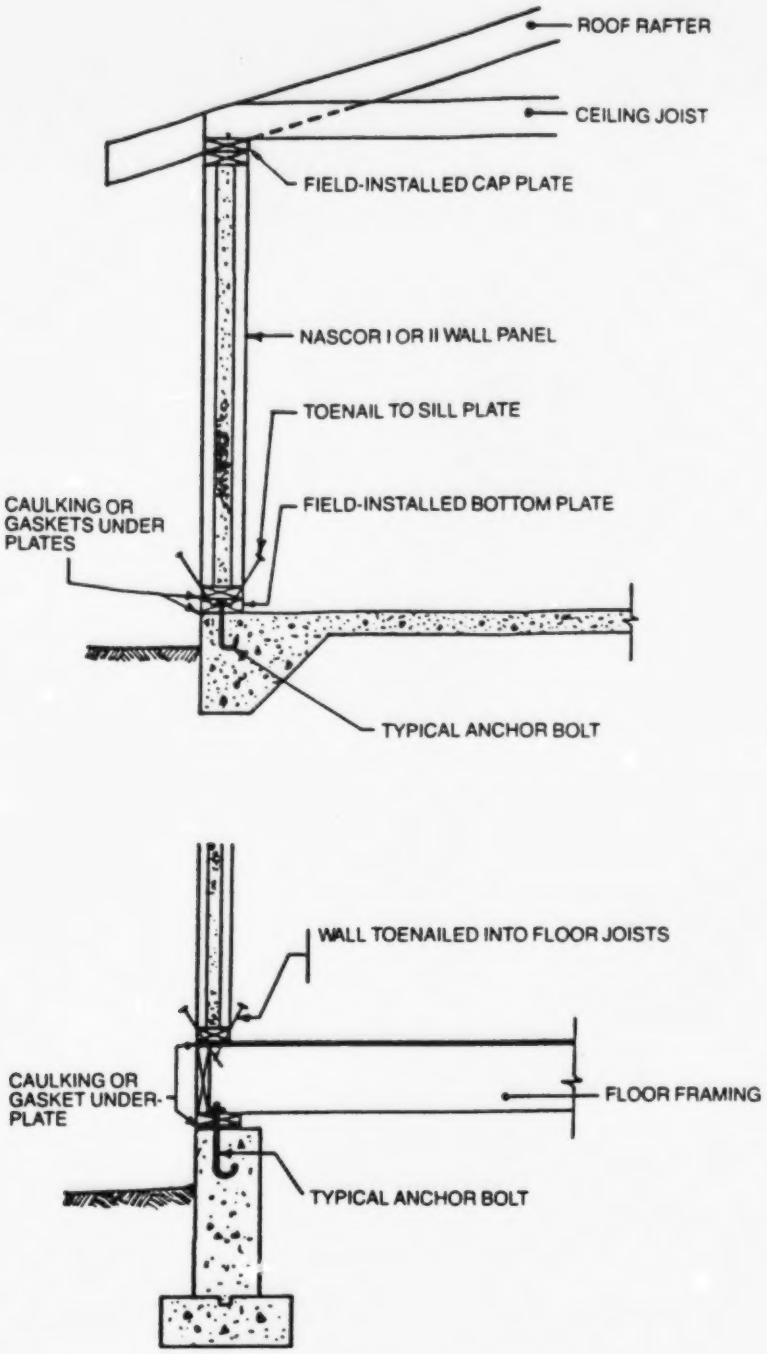


FIGURE NO. 5—TYPICAL INSTALLATION DETAILS

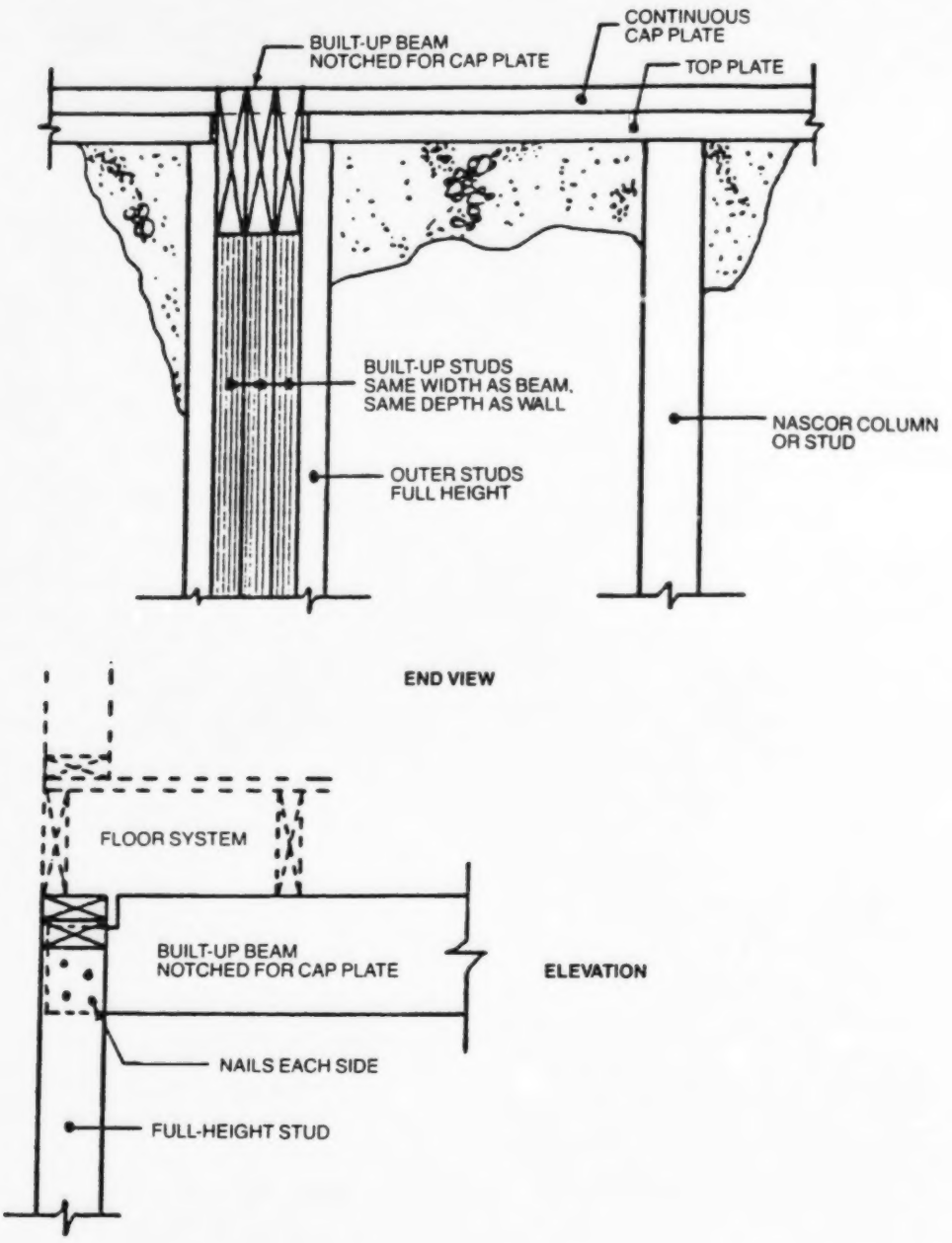


FIGURE NO. 6—TYPICAL BEAM POCKET NASCOR I OR II WALL SYSTEM